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**The delivery of primary dental care in a training environment through team working: implications for dental skill mix in England**

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**THE DELIVERY OF PRIMARY DENTAL CARE IN A  
TRAINING ENVIRONMENT THROUGH TEAM  
WORKING: IMPLICATIONS FOR DENTAL SKILL MIX IN  
ENGLAND**

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## Abstract

**Background:** In primary care dentistry, strategies to reconfigure the traditional boundaries of various professions by task sharing and role substitution have been encouraged in order to meet changing oral health needs. Training dental professionals as a team in order to encourage collaborative practice has been part of this agenda. The focus of the first part of this research is the study of patients and the care activities at the University of Portsmouth Dental Academy (UPDA) and its predecessor organisation. This is a primary care learning institution, where mid-level dental providers; hygiene-therapists (HTS) and dental nurses (DN), train together as a team with dental students on an outreach placement. UPDA was established in September 2010, as a joint venture between the University of Portsmouth's School of Professionals Complementary to Dentistry (SPCD) and King's College London Dental Institute (KCLDI), with the objective of improving team working.

**Aim:** The aim of this research was to investigate the patient base, treatment activity and skill mix practice at a primary dental care team training centre prior to, and after, its establishment, and to model the potential for skill mix use in national primary dental care based on the undergraduate training experience in this centre.

**Methods:** This research involved a case study and an operational research modelling exercise. The former was undertaken using cross-sectional electronic patient management data from UPDA, extracted in two phases: a pilot, which covered two years around the period of UPDA's establishment [2009/10 and 2010/11], and the main data spanning a four-year period before and after UPDA was established [2008/09 and 2011/12]. The data were used to investigate the patient base, expressed treatment needs and skill mix practice using univariate, multivariate and multilevel regression analyses. An operational research model and five alternative scenarios to test the potential for skill mix use in primary care were developed, as informed by the model of care at UPDA, professional policy including scope of practice, and contemporary evidence based practice. The five scenarios included: 'No skill mix', 'UPDA model nationwide', 'Direct access', 'More prevention' and 'Maximum delegation'. The scenario outputs were clinical time, workforce numbers and salary costs.

**Results:** The pilot data findings from 4,343 patients suggest that there was a significant change in the patient base when the new services were initially instituted: the new patient base was

older (on average 4.7 years older  $p=0.001$ ); with more patients non-exempt from payment 56.8% (994) to 71.4% (1,853) ( $p=0.001$ ) with lower deprivation scores; 24.5 (95%CI: 23.8, 25.2) cf to 22.3 (95%CI: 21.7, 22.8); however, there was an increased likelihood of attending in the post-expansion period for patients with a higher geographical barriers to services score, i.e. those further away from services were more likely to attend the new expanded service (0.7%; OR: 1.007 (95% CI: 1.002 to 1.012). From the main extract analysis 10,341 closed/completed treatment plans which were undertaken on 6,351 patients seen over the four-year study period showed an increase in the proportion of patients completing care plans who were in the age groups of 45-54 years and 55-64 years and adult non-exempt from NHS charges. Increasing age was associated with a higher volume of expressed treatment need in general. Logistic regression analysis showed statistically significant association  $p<0.05$ : between having received common treatments at least once in the four-year period. Payment exempt adult patients were more likely to receive all common treatments compared with the non-exempt: partial dentures (x2.6), tooth restorations (x2.1), instruction/advice (x2), tooth extraction (x1.8) and scale/polish (x1.7). The least deprived were 50% more likely to have scale and polish and 50% less likely to have tooth extractions than the most deprived. Smokers compared with non-smokers had a higher likelihood of receiving tooth restorations (57%), instruction/advice (x4), scale/polish (x1.7), tooth extractions (x2) and partial dentures (x2.6). Females patients were 20% less likely a tooth extraction or a restorations compared to male patients. Multilevel analysis indicated that the area of residence explained 7% of the variance in rate of instruction/advice, 3.8% in scale and polish and 2.8% of the variance in tooth extractions. From a sub-sample data of patients and treatments coded by provider of care  $n=2,063$ , 55% of patients had been delegated to hygiene-therapy students at least once and 46% of coded treatments had been delegated. A significantly higher proportion of children were delegated compared with adults (85% cf 50%;  $p=0.001$ ). Similarly adult smokers were delegated at a higher rate compared with non-smokers ( $p=0.01$ ). The rate of delegation of different treatments also varied, with preventive treatments highly delegated (85-90%) and restorative work moderately delegated (60%). The operational research model suggested that the majority of clinical time in NHS primary care is spent on tasks that could be delegated to dental care professionals (DCP). While 45-54 year old patients received the most clinical time. Using estimated NHS clinical working patterns, the model suggested that NHS workforce numbers and salary costs to meet the dental demand in 2011/12



for each scenario were i] 'no skill mix' dentist only scenario would require only 81% of the dentists currently registered in England. ii] The 'UPDA nationwide' scenario would lead to 29.5% of clinical time delegated to hygiene-therapists and a 357% increase in hygiene-therapists and only 57% of the dentists currently registered in England would be required and this would lead to a 19% salary cost saving cf. the 'no skill mix' model. iii] Minimal 'direct access' scenario where 70% of examinations were delegated and UPDA's model of skill mix was practised would require 40% of registered dentists and eight times the number of hygiene-therapists' registered; this would save 38% salary cost cf. 'no skill mix'. iv] 'More prevention' i.e. increasing fluoride varnish from 13.1% to 50% and maintaining UPDA's model of skill mix, would require 4.7 times the number of hygiene-therapists' and 57% of registered dentists. It would be a 1% salary cost saving cf. 'no skill mix'. v] 'Maximum delegation' scenario with all care within hygiene-therapists' jurisdiction delegated at 100% except restorations and radiographs (50%), showed that only 30% of registered dentists would be required and ten times the number of hygiene-therapists' registered. This scenario could have a 52% salary cost saving cf. a 'no skill mix' scenario.

**Conclusion:** The patient base in this primary care training facility represented a wide range of the societal spectrum as would be expected in general primary care practice. There was a significant change in patient base following introduction of new services and team training, to an older, more non-exempt and more geographically deprived patient population. The trend in care was associated with socio-demography and indicated increasing expressed treatment need from middle-aged patients, males and adults who would have normally had to pay for care. Over the four-year study period, routine treatments such as instruction/advice and tooth restorations, which can be undertaken by hygiene therapists, were common and patients were more likely to receive them with increasing adult age, smoking and being an adult exempt from payment. More advanced care such as tooth extraction was more common for the most deprived and smokers when compared with their counterparts. Children and adult smokers were more commonly delegated to hygiene-therapy students. Alternative scenarios based on wider predictors of expressed treatment need, changing regulations on the scope of practice and increased evidence-based practice, suggests that majority of care in primary dental practice can be delegated to hygiene-therapists and there is potential time and salary cost saving if the

majority diagnostic tasks and prevention were delegated. However, this would require either more training or enhancing of roles of mid-level dental providers.

## **Abbreviations**

ADHS	Adult Dental Health Survey
CAIPE	Centre for the Advancement of Interprofessional Education
CDHS	Child Dental Health Survey
CfWi	The Centre for workforce intelligence
COHO	Community oral health officer
DBOH	Delivering Better Oral Health tool kit for prevention
DCP	Dental Care Professionals
DENTASSim	Dental Treatment and Skill mix Simulation model
DMFT	Decayed Missing Filled Teeth
DNS	Dental nursing students
DT	Dental therapist
DS	Dental students
EPMD	Electronic patient management data
GBS	Geographical Barriers to deprivation score
GDC	General Dental Council
GDP	General dental practitioners
GIS	Geographical Information Software
HT	Hygiene-therapist
HTS	Hygiene-therapy students
IMD	Indices of Multiple deprivation
KCLDI	King's College London Dental Institute
LSOA	Lower layer super output area
MSOA	Middle layer super output area
NHS BSA	National Health Service Business Service Authority
OHT	Oral Health Technician

PCT	Primary Care Trust
PMS	Patient Management System
ROC	Receiver operator curve
SPCD	School of Professionals Complimentary to Dentistry
SQL	System Query Language
UPDA	University of Portsmouth Dental Academy
WTE	Whole time equivalent

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# Chapter 1 Introduction

## 1.1 Introduction to thesis

Within healthcare generally, there is increased emphasis on how changing the skill mix of the workforce can assist with addressing health service demands, rising costs and unmet need (Dal Poz et al., 2010, World Health Organization and Global Workforce Alliance, 2014).

Within primary care, which is the lynchpin of healthcare systems, skill mix optimisation strategies that involve improving flexibility of the health workforce in order to improve health care coverage are encouraged (World Health Organization, 2013b, Department of Health, 2014b). These strategies involve altering 'the mix of skills or competencies possessed by individuals in an organisation' (Sibbald et al., 2004). In addition, contemporary educational strategies embracing interprofessional training are increasingly recommended to improve teamwork and collaboration between different health professionals and in turn to improve use of skill mix in their future roles (World Health Organization, 2013a).

In England, health workforce and education policies are now geared to developing a flexible workforce, able to cope with changing health needs through the use of increased skill mix and team working (Department of Health, 2012a). With the majority of dentistry in England delivered through primary dental care, there is an increasing emphasis on students, from different dental disciplines, being trained in teams and in primary care outreach settings, as the composition of the dental team expands and the workforce becomes more professionalised (General Dental Council, 2011, General Dental Council, 2012). In addition there is increasing reorientation of primary dental care towards prevention (Department of Health and British Association for the Study of Community Dentistry, 2007, Department of Health and British Association for the Study of Community Dentistry, 2009, Public Health England et al., 2014) and the delivery of services through patient care pathways (Steele and O'Sullivan, 2011, Steele et al., 2012, Department of Health, 2010a). However, there is a dearth of evidence on the practice of DCPs within primary dental care and room for more research (Harris and Sun, 2012a, Harris and Sun, 2012b), and evidence of difficulties in the organisation of skill mix use in general dental practice in the UK (Gallagher and Wright, 2002, Evans et al., 2007).

This research involves the case study of a primary dental care training centre in the south of England, which trains dental students together with dental hygiene therapy and dental nursing students, using interprofessional training techniques, with the objective of improving future teamwork in practice to realise the potential of the dental team in their future roles. The aim of the research was to investigate the patient base, treatment activity and models of skill mix practice at this primary dental care team training centre prior to, and after, its establishment, and to model the potential for skill mix use in national primary dental care, based on the undergraduate training experience in this centre.

Interprofessional training is more widely practised in general health than in dentistry (Morison et al., 2008). Barr (1998) defines interprofessional learning as a collaborative process that provides members of different professions with an opportunity to understand each other's roles and operations, while meeting requirements of their duties. It is suggested that interprofessional training improves the capabilities of health professionals, aiding them to work more effectively across boundaries (Clifton et al., 2006, World Health Organization, 2013a); this recommendation is, however, made conditionally due to limited evidence on the impact of interprofessional training on some forms of teamwork (World Health Organization, 2013a).

The University of Portsmouth Dental Academy (UPDA) and its predecessor organisation, which are the focus of this research, have been educating students using interprofessional training or team training strategies in a primary care setting. UPDA is an outreach setting for dental students from King's College London (KCLDI), and an established university training centre for dental care professional students (DCPs). The facility mimics primary care by utilising a live contract system similar to the NHS General dental services. In addition, the students work in practice teams which include, on average, five dental students and four hygiene therapy students. Although the service is free at the point of delivery, students have the responsibility to meet the contractual obligation of a dental contract similar to GDS while providing an evidence based pathway of care. How, and what, the students learn is fundamental to preparing them for their future professional environment. Therefore, there is important learning to be gained from this research on how skill mix can be used to meet patient treatment needs beyond the undergraduate training environment; particularly in the presently reforming NHS primary dental care.

There is significant evidence to suggest that the learning from community and outreach training services, has substantial impact on career practice (Cunningham et al., 1985, Piskorowski et al., 2012, McQuistan et al., 2014). Educators view outreach team training as an opportunity for students to gain confidence and clinical maturity (Eriksen et al., 2011). Dental schools in the UK and Ireland suggest this approach as ideal to prepare students for future practice (Lynch et al., 2013).

Only a few studies, mostly qualitative, have been conducted on inter-professional training in dentistry in the UK (Morison et al., 2008, Ross et al., 2009, Morison et al., 2011, Reeson et al., 2013). These studies have mainly reported on impact of interprofessional training on soft skills such as communication and understanding of roles (Morison et al., 2008, Ross et al., 2009, Morison et al., 2011, Reeson et al., 2013). The dearth in evidence is largely seen around information on hard skills or sharing of clinical tasks (Reeson et al., 2013); elements key to the promotion of skill mix. The recommendation is for more research into the impact of inter-professional learning during training, and beyond the undergraduate learning environment (Reeson et al., 2013). For this reason, this research has focussed on investigating patients' treatments and the sharing of clinical tasks, which provides new knowledge not only for the impact of team training on task sharing during undergraduate learning, but also in relation to skill mix use in primary dental care in general, for which there is little evidence (Harris and Sun, 2012b). Parallel doctoral research at King's is outlining the qualitative aspects and attitudes experienced by those training as a team at UPDA (Colonio-Salazar, 2014). The findings from both studies provide a balance of information on aspects of working together in team training. While independently, this study offers opportunities to explore the aspects related to the delivery of primary dental care and the use of skill mix; providing important timely insight into how all the members of the dental team can contribute to meeting patient needs in primary dental care in England.

In summary the research involved an exploratory case study of a primary care dental training environment using electronic patient management data. This was followed by a supply and demand operational research modelling exercise, informed by the learning from case study and professional policy on the scope of practice of dental professional groups. Only theoretically generalisable findings from the case study were used to develop the supply and demand

operational model. The exploratory approach provided an opportunity to engage openly in all findings from the data. In the next section a description of the study site is provided, covering its establishment and operational structure.

## **1.2 Research site background**

The University of Portsmouth Dental Academy (UPDA) which opened in September 2010 is a collaborative venture between King's College London Dental Institute (KCLDI) and the University of Portsmouth's former School of Professionals Complementary to Dentistry (SPCD). Prior to the establishment of UPDA, only DCPs were trained in SPCD, now, following expansion, the UPDA is a centre for the training of hygiene-therapists (HTS) (also known as dental therapists ) and dental nurses (DNs), and provides outreach training for final year dental students (DS) in their final year at King's College London. DS work alongside the HTS and DN in practice teams that aim to simulate a primary care setting (Radford, 2011). This provides an opportunity for the dental students from King's College London to gain training in primary care moving away from secondary care where the majority of undergraduate training takes place in England (Daly et al., 2013, Radford, 2011). And for both groups of students this was an opportunity to work directly as a team like in primary care.

When SPCD was established in 2004 to provide training of HTS and DNS, it was the first institution of learning for professionals complementary to dentistry that was independent of a dental school in the UK (Portsmouth Academy, 2010), since the New Cross school of dental therapy, which closed in the early 80s (Nuffield Foundation, 1993). The DCP students in training at the SPCD received their patients by referrals from qualified dentists practising at the now closed NHS William Beatty Dental Service (WBDS) attached to the SPCD. This was because DCPs could only see patients following prescription from a dentist. WBDS was closed on June 30th 2010 on the establishment of UPDA. Some of the dentists from WBDS moved to work as tutors in the new Academy. This meant that the tutors who had experienced the high volume practice patterns involved in primary care and the local environment, were now training the students; this is considered beneficial for the students (Elkind et al., 2007). Elkind et al. (2007) propose that the desirable characteristics of outreach teachers are those which enable them to cope in this environment, together with a student-centred teaching style, and the appropriate

knowledge. The DS from King's College London now carry out the role of the qualified dentists of the WBDS, and assess and refer patients as appropriate to HTS.

### **1.2.1 William Beatty Dental Service**

The William Beatty Dental Service (WBDS) was a University of Portsmouth owned dental practice run by three dentists working full time. All hygiene therapy work was referred to the HTS in SPCD; however, there was a brief period of about two months in the seven years when a registered hygiene/therapist was employed. WBDS received patients primarily through walk-in, word of mouth and internal advertising within the university. Recruitment was on Tuesdays, Wednesdays and Fridays. On each of these days, four new patients were seen by the dentists on a 'first come first seen' basis. In only four occasions, during the period WBDS was open, did the practice use a Dental Helpline to recruit new patients; Nov 2009 (50 patients) Jan 2010 (50 patients) February 2010 (28 patients) April 2010 (26 patients).

### **1.2.2 Establishing UPDA**

According to the proposal for the establishment of the Academy, UPDA was founded on a cost-effective model, focussed on integrated learning, teamwork in dentistry, increased preventative services, enhanced dental treatment for the population in Portsmouth, general health promotion activities and facilitation of continuing professional education (Portsmouth Academy and Kings College Dental Institute, 2008). This placed the Academy's priorities in line with prevailing dental service agenda in England.

To support the Academy's primary care training structure they entered into a Personal Dental Services (PDS) plus dental contract. The PDS plus contract, which is used nationwide, and has been referred to by as a 'locally sensitive contract' due to the inclusion of locally relevant key performance indicators in the contract (Milsom et al., 2008). UPDA's PDS plus contract has included national as well as local key performance indicators on health promotion for the City of Portsmouth, such as diet advice and chlamydia screening signposting (up to 2011). These local performance indicators were informed by the findings from Portsmouth's Joint Strategic Needs Assessment (JSNA) (NHS Portsmouth CCG & Portsmouth City Council, 2013). The PDS plus contract is explained in greater detail in Section 1.2.5.

Following UPDA's establishment all services were rendered free for all patients. This was a bold step to eliminate a known barrier to dental service access in England, which has been highlighted by research (Marshman et al., 2012); a barrier especially impacting on older patients in England (Borreani et al., 2010, Borreani et al., 2008). The free service was also particularly viewed as a useful approach to improving access of underserved groups in Portsmouth; an area recognised for poor dental access rates (NHS Dental Public Health Team, 2011). UPDA received funding from the remuneration from the PDS contract and Higher Education Funding Council for England (HEFCE).

### **1.2.3 Structural and capacity changes at UPDA**

To establish UPDA, significant structural changes were necessary. First, a new wing that housed an additional 20 dental units was added to accommodate the twenty dental students who would join DCPs weekly. This brought the total number of dental bays and units to 44. Second, residential accommodation had to be acquired so that students could be based in the area during their weekly attachment. A total of 80 final year dental students attend outreach in Portsmouth from KCLDI on a rotational basis each academic year, and another 80 remain in London attending outreach training at the Maurice Wohl clinic in Denmark Hill, South London (Radford, 2011). More recently the London-based students have their primary dental care experience in West Norwood health and Leisure Centre, a 14-chair dental facility within a brand new health and leisure centre jointly developed by the NHS and the Local Authority (Lambeth Council, 2014).

DS arrive on Monday evening and at 9.00 am on Tuesday morning practice team meetings are held between both teaching staff and all the professionals in training. DS refer patients whom they find suitable for delegation to a HTS within their practice teams after assessment and care planning, thus simulating a primary care practice in an NHS setting. It is also to ensure continuity of care for patients within the same practice team. The DS delegate care as in the best interests of the patient and is educationally suitable.

The dental students each work for 3.5 days in clinic, and the 2nd and 3rd years HTS (24 per year cohort) work 2.5 days in clinic on the UPDA campus. Student Dental Nurses only work as assistants to the clinical DS and HTS, and do not provide clinical or oral health education to



patients. Qualified dental nurses also work on the clinic at a ratio of 8 to 20 students. The HTS programme is a BSc Hons over three years while the Dental Nursing programme (Diploma) is shorter (12 months). There are 20 nursing students in any given academic year.

**Table 1-1** shows the structure of the four practice teams and the representation of different members of the dental team within them.

**Table 1-1 UPDA student practice teams structure in 2010/11**

<b>Practice teams</b>	<b>Solent</b>	<b>Langstone</b>	<b>Hamble</b>	<b>Meon</b>	<b>Total</b>
<b>Dental Students</b>	20	20	20	20	80
<b>Dental nursing student</b>	5	4	4	4	17
<b>DH/T Year 3</b>	6	5	5	5	21
<b>DH/T Year 2</b>	5	5	5	5	20
<b>DH/T Year 1</b>	6	5	7	6	24

Note:

Reducing numbers in HTS due to drop-outs.

Twenty DS across the four teams attend in a one week in four rotations per year

Source: University of Portsmouth Dental Academy

Within each practice team there are five DS and six HTS weekly. The ratio of DS to HTS varies from 1:1.4 every year to 1:1 in later years. This ratio has been known to drop to less than 1:1 due to high drop-out rates among HTS. This aspect of the Academy seems reflective of Galloway et al (2002) recommendation of a 1:1 ratio of dentist to DCP for increased productivity (Galloway et al., 2002).

The team training model at UPDA is only in the form of clinical collaboration, all other activities are learned separately (Portsmouth Academy and Kings College Dental Institute, 2008). The way in which they work collaboratively in clinic can be described as 'interprofessional training', which is defined by Barr and Low (2012), as 'when two or more professions learn with and about each other'. They suggest that this improves collaboration and quality of care (Barr and Low, 2012). The training at UPDA involves teamwork guided by tutors in the practice team structure, with dental student and DCP students sharing clinical care. There are no rules on delegation practice; delegation is undertaken where it is in the patient's best interest, academically required and suitable.

UPDA is not designed to serve merely as a routine high street practice, as there was an expectation that the Academy would provide a course of treatment for patients with high dental needs, establish dental health, and then discharge them to other local dental practices. This

was partly to meet an unfulfilled dental need and to ensure adequate educational treatment for the professional in training. Patients who are treated at the Academy are expected to experience an all-encompassing pathway of dental care, involving treatment from the most appropriate member of the dental team, and the expected result is good oral health, with referral into regular systems of routine dental care or secondary care where necessary. This, however, is not always the case as some patients return for more than one course of care. For each course, UPDA's patient management system facilitates a care pathway that allows risk assessment as a part of the patient journey, similar to the new dental contracts under pilot (discussed in detail in Section 2.6.6).

Dental treatment at the facility includes all treatments that could be expected in a regular NHS high street dentist: oral health promotion, tooth restorations, preventative treatment, periodontal treatment, crowns, bridgework, dentures and root canal tooth restorations; it does not include complex or cosmetic treatments (Portsmouth Academy and Kings College Dental Institute, 2008).

#### **1.2.4 Patient access at UPDA**

After the expansion and the service contract changed, patient access routes also changed. Now, patients mainly access through the use of the Solent Dental Helpline (NHS Foundation trust :South Central ambulance service, 2014). The patients who call the helpline could be from anywhere within South Central, and if they were willing to attend appointments at UPDA they would be booked into the UPDA system. The operators of the Solent Helpline only source patients when the Academy is recruiting when there is free resource. Patients are then booked directly by the academy's patient administration staff into the dental students' books for assessment and care planning.

The use of the helpline for prospective patients was part of the terms of the new PDS contract. And the support for the use of helplines was based on the low dental access rates nationwide (Department of Health, 2011b). As dental students joined UPDA, it was recognised that the present patient pool would not be adequate for either educational or activity purposes. Therefore, at the outset, the Academy undertook a local recruitment drive in addition to the helpline. UPDA staff informed the local community of the expansion of the services and invited

them to make use of this new free dental service. This was undertaken in local fairs, through the intranet (at the University of Portsmouth) and internet. Appendix 10.6.1 shows a chart of the care pathway received by a patient within the system at UPDA.

The patient base for UPDA comes from Portsmouth City and its environs. See Section 10.6.2. Portsmouth is a city on the South Coast of England in Hampshire. It is the second most densely populated city in England, second to London with an estimated population of 191,100 in 2010 (Hampshire County Council, 2009), which rose to 205,100 in 2011 (Hampshire County Council, 2014). Between 2013 and 2021 Portsmouth's population is projected to grow by 4.5% (NHS Portsmouth CCG & Portsmouth City Council, 2013). Eighty-four per cent of the population is White British and the age structure of the city is relatively young with the majority of the population aged below 40 years. The largest age group is between 20-24 years (Hampshire County Council, 2014). This may be attributed to the presence of the University of Portsmouth and naval bases.

Portsmouth is ranked as the 76th most deprived local authority (LA) out of 326 in England according to the 2010 Indices of Multiple Deprivation (NHS Portsmouth CCG & Portsmouth City Council, 2014). In several public health indicators, Portsmouth falls below England averages (Public Health England, 2013b). The prevalence of smoking amongst adults in Portsmouth is 26%, and obesity among reception year children is higher than the average for England (NHS Portsmouth CCG & Portsmouth City Council, 2014).

During the period covered by this study, Portsmouth City Teaching Primary Care Trust commissioned health services within the City of Portsmouth. This has since changed to a national commissioning body following the NHS reforms (Department of Health, 2010a). Dental service access for those in the most deprived areas has been a priority in Portsmouth due to survey results that have consistently shown that children in the poorest areas of Portsmouth have lower than average dental access rates (NHS Portsmouth and Portsmouth City Council, 2012). In the period just prior to the start of the proposal to establish UPDA in 2008, only 17.8% of children in the city had "sound teeth" (NHS Portsmouth City Teaching Primary Trust, 2007). This figure was lower in the deprived areas (17.2%) and even lower amongst children from ethnic minority backgrounds (16.5%) (NHS Portsmouth City Teaching Primary Trust, 2007). The

inequalities in the health of children in the deprived areas of Portsmouth compared with the more affluent is maintained to date (NHS Portsmouth CCG & Portsmouth City Council, 2014) and with the well-known link between deprivation and poor oral health status (Sheiham, 2005, Watt and Sheiham, 1999), efforts to improve the representation of deprived groups within the patient pool attending dental services such as UPDA has been a priority.

#### **1.2.5 The dental contract in UPDA**

The PDS Plus contract held by UPDA, specifies payments through a three-arm system which includes access for unique patient groups. The three arms are outlined as follows:

**Services:** Calculated in UDAs. A 'UDA' is a "Unit of Dental Activity" which is undertaken by an NHS dental service provider

**Access:** Calculated according the number of new and unique patients attending the practice (these are patients who are defined by the NHS as having not attended the practice in the preceding 24 months).

**Performance:** This are measured by key performance indicators (KPI's) and include national and local indicators. The indicators are procedural operations that have to be completed for each patient, e.g. dental assessment, fluoride varnish application.

#### **1.2.6 The patient management system**

Managing of patients and reporting on the contract to the NHS Business Service Authority (NHS BSA) can be done via an electronic system or return of FP17 forms. In UPDA this is conducted electronically. UPDA's electronic patient management system clinical plus, is a widely used general practice system developed by Carestream Dental Ltd, and it collects patient socio-demographic details, care details and is used to aid risk assessment and care pathway planning (Carestream Dental, 2011).

It has been suggested that the PDS Plus contract does not encourage the use of skill mix due to the UDA system (Brocklehurst and Tickle, 2011a). Furthermore, the payment system makes it complex to establish how to remunerate DCPs involved in a treatment plan, because the dentist has to be involved in opening or closing a treatment plan. Since 2010 a new dental contract has been under pilot in England and since 2013 all dental contracts are held centrally by a national

commissioning board (NHS England) as enacted by the 2010 White Paper, 'Equity and Excellence: Liberating the NHS', (Department of Health, 2010a), but negotiated locally.

### **1.2.7 Summary**

A team driven dental workforce that optimises on skills of all members of the dental team is supported by health policies in England (Department of Health, 2010a, Department of Health, 2012a) and education policies that encourage team working (General Dental Council, 2011, General Dental Council, 2012, Health Education England, 2014b). There is, however, relatively little research on how this can be achieved practically in general dental practice and further hindered by the lack of management information on the use of skill mix in general practice (Harris and Sun, 2012b). This presents a relevant issue for redress in light of changing patient needs (Gallagher and Wilson, 2009, Steele and O'Sullivan, 2011) and a changing NHS service (Department of Health, 2010a).

The case study site for this research, was established to integrate the training of DCPs (dental hygiene-therapists and dental nurses) with outreach training of dental students preparing them to work in the future NHS. The organisational primary care structure of UPDA and its predecessor organisation SPCD has presented an opportunity to investigate the relationships between delivery of primary care, patients' needs and skill mix use, the results of which have been used to model potential for skill mix models in alternative scenarios for England's NHS primary care services. The findings from this research advance the knowledge regarding skill mix in practice, and the potential contributions of various members of the dental team to the provision of services in primary dental care.

### **1.2.8 Overview of Thesis**

The thesis is reported in nine further chapters. Chapter 2 contains a review of the literature (overleaf). The aim and objectives are outlined in Chapter 3. Chapter 4 contains the methods and methodology. There are four chapters of results: Chapter 5 provides the findings on the patient base, deprivation and geography in UPDA; Chapter 6 describes the expressed dental treatment needs and their predictors based on UPDA analysis; Chapter 7 provides results of the analysis of skill mix in practice at UPDA; Chapter 8 gives a description of the operational

research exercise development and the results of the scenario testing. Chapter 9 presents a discussion of the findings and conclusions from the research, and finally, Chapter 10 contains the recommendations arising from this research.

## **Chapter 2 Literature review**

### **2.1 The literature review search strategy**

This chapter is presented as a synthesis of the relevant literature within the scope of this study. The literature search process involved a mind mapping exercise that centred on the research study title 'modelling dental skill mix from a primary care training institution'. The mind map, in Appendix 10.6.3 and Appendix 10.6.4 shows the electronic search words used, was used to outline the keywords for a literature search. A similar approach to the use of Medical Subject Headings (MeSH) terms in *Medline* and *ClinicalTrials.gov* registry was adopted in this research with modification. While using MeSH terms in literature searches involves identifying a set of terms, naming descriptors in a hierarchical structure, to enable a search at various levels of specificity for the subject (Cochrane library tutorial, 2011), in this literature any words thematically related to the key aspects of the study 'Dental skill mix in a primary care team training institution and England', were used as central points and related terms were added. The emphasis of the process was on obtaining a wide breadth of terms rather than hierarchy within the search terms.

The mind mapping process facilitated a sequential increase in the number of relevant terms for inclusion in the literature search. After articles were retrieved, their reference lists were reviewed and previously unidentified relevant concepts and papers were added to the list of search terms. This system of literature searching provided a wider range of titles - approximately 70. These were run with truncation on MEDLINE, OVID and Web of Knowledge. Additional searches were run on e-books Lib, to obtain books that would be relevant to the literature review. Policy and professionally relevant documents were obtained by searches on official Department of Health website publication sections and the National Archive. The literature was updated at regular intervals while the research study was ongoing, using an alert system set up on Google Scholar

and hand searches which were undertaken periodically on Medline, OVID and Web of Knowledge to ensure that recently published literature was included.

## **2.2 Introduction to the literature**

This literature review explores aspects related to the development of a dental team capable of meeting the changing oral health needs in primary care. Section 2.3 examines the nature of the relationship between the effort to meet health needs, and the efforts to develop an appropriate health workforce. Section 2.4 explores primary health care as the vehicle for the promotion and maintenance of health. Section 2.5 describes dental care in England up to the present point of reform. Section 2.6 examines the drivers for change in primary dental care including the philosophical aspects of reform in health care. Section 2.7 examines the health workforce and details the members of the dental workforce and their roles; this includes a critique of the process of role development for dental auxiliaries or dental care professionals. In section 2.8, skill mix and its implementation and associated challenge, are reviewed. Section 2.9 considers workforce planning. Section 2.10 outlines the role of contemporary techniques of education in primary care and the process of team development. This last section highlights the potential for research in primary care institutions practising contemporary methods of team training, to advance the knowledge on the potential for dental teamwork in primary care. Finally, a summary of the literature is provided.



## **2.3 Health and health needs**

### **2.3.1 Introduction**

There is a global drive to develop an appropriately skilled health workforce or ‘human resources for health’, to work to meet the changing need for care and demands on health systems (World Health Organization and Global Workforce Alliance, 2014). With an increasingly ageing population the nature of demand on health services requires flexible health workers capable of working collaboratively to meet patient and population needs (United Nations Department of Economic and Social Affairs Population Division, 2013). Therefore, as a foundation to the literature, this section defines health and debates the process of identifying and prioritising health needs in health care systems. This also includes outlining the role of wider social determinants of health in the process. This will establish how these factors influence proposed education, staffing and working arrangements for health workers.

### **2.3.2 Health**

Health was described by the World Health Organization (WHO) in 1946, as ‘a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity’ (World Health Organization, 1946). In 1978, the international health community reaffirmed in the Alma Ata declaration that health as ‘a state of complete physical, mental and social wellbeing, and not merely the absence of disease or infirmity, is a fundamental human right and that the attainment of the highest possible level of health is a most important world-wide social goal whose realisation requires the action of many other social and economic sectors in addition to the health sector’ (World Health Organization, 1978). This later description of health is accepted by most for its holistic approach and is currently a central thread in global health promoting strategies (World Health Organization, 2013a, World Health Organization, 2013b, World Health Organization and Global Workforce Alliance, 2014). It moves away from a focus on vertical disease intervention to a social approach to maintaining and improving health, and reaffirms the role of society, behaviours and organisation in the health of populations (Bryant, 1980).

‘Health for all by the year 2000’, was the target after the 1978 declaration and this was seen as revolutionary and a means to improve social justice and equity by some (Bryant, 1980), while others argued a disconnect between ideology and reality in the declaration (Mburu, 1980, de

Kadt, 1982). A large amount of the rhetoric that ensued did revolve around regional differences in health needs, ethical standards and political positions (Mburu, 1980, de Kadt, 1982, Navarro, 1984). Navarro (1984) proposed that the objectives highlighted by the declaration negatively assumed autonomy. He described this as a situation where hegemonic bodies imposed their idea of needs and planned for them independent of an understanding of the actual situation on the ground (Navarro, 1984). Although this was particularly in reference to the situation in developing nations at the time, it could be relevant in the present day, where often ethics, policy and reality collide, leading to lack of success for strategies to improve health service delivery (de Kadt, 1982).

Moving forward to the mid-1980s, a new movement was instituted, which focussed on identifying local health needs before prioritising health and social care strategies (Bradshaw, 1994). This was especially with a view to manage finite resources (Donaldson and Mooney, 1991). Commentators appeared to welcome planning for high volume health services, paying little attention to the appropriateness of the service (Donaldson and Mooney, 1991). It was proposed that ascertaining needs and demand would also aid to plan for the appropriate health workforce (Feldstein, 1999).

In the new millennium there began to be a more patient oriented approach, and a call for more complexity in the process of prioritising needs in order to not only focus on ensuring general health, but also promote equity in health (Baltussen and Niessen, 2006). In the case of ascertaining the supply of health workforce, research evidence begun to grow and suggested that need could be defined restrictively or broadly and this required a wider view of the constituents of demand for health care to include aspects such as time and skills (Zurn et al., 2004, Segal et al., 2008, Segal and Bolton, 2009, Segal and Leach, 2011). It is through this broad understanding of health needs, and the identified role of an appropriately skilled health workforce in meeting needs, that policy positions such as task shifting between health professionals (World Health Organization, 2007b), have been further emphasised in global health strategies (World Health Organization and Global Workforce Alliance 2014).

### **2.3.3 Assessing and monitoring health and oral health needs**

#### **2.3.3.1 Introduction**

There is a benefit in assessing and monitoring health needs so as to engage in appropriate planning for services and human resources. The following sections explore how needs assessment in health has evolved and considers its impact.

#### **2.3.3.2 Assessing health and oral health needs: the evolution**

Scriven and Roth (1978) define needs assessment as 'a determination of the difference between what is and what ought to be'. They go further to emphasise the importance of this process before planning any intervention, but acquiesce to the fact that 'one can never know what is ideal or in what quantity the ideal should be' (Scriven and Roth, 1978). Scriven and Roth (1978) describe this as 'the discrepancy'. This approach to the question of need is particularly of importance, as understanding the quantity of need impacts on the supply of services and therefore the workforce requirements.

A useful conceptualisation of need for the health care field has been *Bradshaw's taxonomy* (1978). As one of the earliest widely accepted descriptions of health needs, Bradshaw's taxonomy of social needs (Bradshaw, 1972) provides a choice of categories of types of needs. Although Bradshaw's taxonomy of need was developed with a general societal view, it has served several health policy makers to describe need. The four categories in the taxonomy are:

- i. Normative need is defined by experts and is often the desirable professional standard.
- ii. Felt need is a want, desire which may not become expressed need
- iii. Expressed need is demand or felt need turned into action
- iv. Comparative need has to do with equity

According to Bradshaw in 1994, when asked to reconceptualise his taxonomy of need towards health needs, he explained that on devising the taxonomy 'the world was less harsh'. Bradshaw (1994) described need as too imprecise and complex for description (Bradshaw 1994). He argued that the definition of health need was engulfed within the model of health ascribed (Bradshaw, 1994). And this was based on the situation of the day. Bradshaw (1994) suggested that if the medical model (Helman, 1981), which is a priority based curative approach to need, popular in the period before late 70s was ascribed to, a normative needs approach based on

'doctor knows best' would be prevalent. He argued that if a more social approach was adopted, where wider determinants of health were considered as important, this would be more preferable and more relevant in the present day where inequalities in health existed. Bradshaw (1994) recognised the role of understanding and curing diseases, but saw benefit in prioritising equity in health when assessing health needs. Bradshaw (1994) highlights the challenge in the process, at the same time showing the importance of the process.

Assessing health need has an impact on the health workforce requirement. This is because when 'felt' or 'perceived' need is expressed it turns into demand or 'expressed need', and requires a supply of a health workforce in order to meet its requirements (Segal and Leach, 2011). According to economists, analysing demand in order to plan for supply is justified, as there is an assumption that in allocating their resources, consumers try to maximize their satisfaction, subject to a budget constraint (Feldstein, 1999). This can be argued as inaccurate in the case of health care, as it is well known that actual health needs commonly exceed demand (Cohen 1987). However, in dentistry in the UK, where general dental services are remunerated based on demand (Nuffield Foundation, 1993, Harris and Burnside, 2004), it is worthwhile to have an understanding of expressed treatment needs or demand.

Further still, assessing expressed treatment need may give an indication of the wider amount of unmet need and who is experiencing this unmet need. This can be achieved by analysing the severity of presenting complaints to dental practitioners. For example, a patient presenting with a completely broken down tooth, which cannot be restored and requires extraction, has obviously had a need for care for a long time and presents when its worst, demonstrating a period of unmet need. The reasons for this late presentation or lack of presentation are numerous. Factors such as patients perception and behaviour have been shown to play a role as to whether or not the need is identified and responded to (Baker, 2009); however, in identifying these individuals from their expressed needs, planning can be geared towards addressing barriers to the patients use of service or lack of recognition of need. It also provides an opportunity to identify the trend in treatment needs allowing the appropriately skilled staff to be included in the practice.

This is significant to the perspective of this current research, as the opportunity to scrutinize expressed need is present within UPDA's patient management data. In addition, the omission of cost as a barrier, increases the likelihood that the expressed need (demand) in this set up, is a substantial reflection of actual need, as studies have suggested that if health care services become more accessible by eliminating known barriers such as cost or capacity, the demand for healthcare based on actual need will increase (Asadi-Lari et al., 2003). Therefore, in assessing these aspects of need, a useful understanding can be gained of how to meet needs, using a collaborative workforce. Factors associated with need and service utilisation and the Andersen's model of service utilisation (Andersen and Newman, 1973) are explored in detail in Section 2.4.3.3.

#### **2.3.3.3 Assessing expressed needs to understand oral health care requirements**

Greater understanding of expressed needs and other aspects of meeting demand through supply factors such as time and skill is required. This will support planning for the health workforce. This approach relates to strategies offered by Wright et al (1998) in an adaptation of Gabbay and Stevens (1991) model. They proposes that there is an overlap between, 'needs', 'demand' and 'supply'. They further highlight the importance of considering this overlap when assessing needs and further suggest that in order to appropriately determine priorities through needs assessment there needs to be a balance between clinical, ethical and economic considerations of need, while recognising this overlap (Wright et al., 1998).

Assessing demand as expressed needs presents one of the most efficient ways of planning for human resources (Segal and Bolton, 2009). However, this will depend on including factors affecting demand such as population changes, market shifts and technology (Feldstein, 1999, Zurn et al., 2004, Segal and Bolton, 2009). Segal and Leach (2011) propose that indeed actual needs should be used to plan for human resources; however, as demonstrated, these cannot be fully quantified for those who do not present into formal institutions (Cohen, 1987). Demand (expressed need) has been proven to be a good indicator of need, as Hopton and Dlugolecka (1995) showed in a comparative survey of need and demand of patients attending a single practice. Their findings revealed a link between the volume of demand and the morbidity of health need in patients (Hopton and Dlugolecka, 1995). Also, the complexity of demand should be taken into consideration (Zurn et al., 2004).

Factors such as time to provide care and skill required to treat, varies between patients, and these all contribute to demand as well and would influence the nature of the workforce required (Bulman et al., 1968). According to Segal and Bolton (2009), apart from all these elements of need, societal health service objectives should be included in any demand modelling for the supply of the health workforce. The limitation to this is the lack of adequate data linking need, demand, taking into account the social determinants of health. It falls on researchers to become innovative in linking these data, where available, and using proxies where not. There is a need for research in England to examine the use of routine data to understand expressed need, together with social information to provide a more comprehensive picture of the demands on services and the dental workforce.

## **2.3.4 Oral health needs and monitoring the change**

### **2.3.4.1 Introduction**

In the case of oral health, there have been marked improvements in the prevalence of certain oral diseases. This has led to a shift in the nature of oral health care needs (Petersen et al., 2005a). Consequently, the nature of skills predominantly required by the dental workforce has changed and the emphasis is on maintaining the health of those who have good oral health, as opposed to increased curative services (Petersen, 2003, Petersen et al., 2005b, World Health Organization, 2005a, Petersen, 2008). In addition, the global demographic shift currently being experienced due to an ageing population, which has been accompanied by an increase in non-communicable chronic diseases (World Health Organization, 2005b, United Nations Department of Economic and Social Affairs Population Division, 2013) impacts on the needs of the population.

### **2.3.4.2 How oral health is monitored**

According to global health organisations, the shift in demography has had, and will continue to have a significant impact on the type of care and of patients who attend dental services (Petersen and Yamamoto, 2005, Preshaw and Mohammad, 2005, World Health Organization, 2005b, Petersen, 2009, Better Oral Health European Platform, 2013). The global share of older people (aged 60 years or over) increased from 9.2 per cent in 1990 to 11.7 per cent in 2013, and will continue to grow as a proportion of the world population, reaching 21.1 per cent by 2050 (United Nations Department of Economic and Social Affairs Population Division, 2014). There are now much older patients with other co-morbidities requiring health care, and the nature of care is more complex for this older population who also happen to be retaining their teeth longer (Better Oral Health European Platform, 2013). It is due to such shifts that careful monitoring of health needs remains part of the health care and health workforce planning agenda.

Surveillance and monitoring of changing oral health need is recommended by the WHO (Petersen, 2003). This is infrequently undertaken in most countries; however, such regular monitoring could offer accurate timely information on population measure of health need and facilitate appropriate planning for health workforce and services. In fact, according to the WHO,

community oral health assessments should be conducted at least every 5 to 6 years (Petersen et al., 2005a). Daly et al. (2013) have described monitoring of changes in the oral health status of the population as a 'primary process in gaining an understanding of the normative needs of a population' (Daly et al., 2013), which would have significant impact on the workforce requirements.

The type of monitoring undertaken at the population level is commonly achieved through large surveys that question various parameters of oral health (Hobdell et al., 2003). Examples of national surveys for oral health are the Adult Dental Health Survey (ADHS) and the Children's Dental Health Surveys (CDHS) in the UK and the National Survey of Adult Oral Health (NSAOH) in Australia. These decennial surveys capture the trend in oral health of their populations based on indicators of tooth retention, caries, treatment and dental attendance behaviour etc. Surveys provide a cross-sectional picture of the oral health needs of the population, using a representative sample (Helman, 1981). This type of information should inform health policy and planning and may be used in forecasting and modelling the future service and workforce demands as has been shown in countries like Holland (Burgersdijk et al., 1994). Indeed surveys are useful, but costly and time consuming to conduct (Choi, 2012). The recruitment of subjects can be a difficult task (Neale, 2009), and the length of time between national surveys is a reflection of the resource required to implement them. It is important that their findings are used to benefit the population.

#### **2.3.4.3 A need to improve monitoring of oral health needs**

Information systems present as a helpful alternative and the WHO support their use to monitoring health needs proposing that they allow ongoing data collection, analysis and interpretation of population health data in a timely manner (Petersen et al., 2005a). Also, information systems do not rely on self-reports like surveys, limiting the possibility of recall and social desirability biases (Neale, 2009). Although these surveys provide useful data, they are undertaken only periodically due to logistics and cost, and this may lead to long periods between surveillance information, which can prove harmful to timely health service interventions. The accuracy of most surveillance data, whether electronic or population surveys, can be challenged; however, the benefits of periodic monitoring from electronic information



systems outstrips these challenges. And with the growing use of electronic systems in ordinary general practice, there is potential to collect a rich volume of useful information.

In Europe, programmes such as Council of European Chief Dental officers Database (CEDCO database) and European Global Oral Health Indicators Development project (EGOHID project) have attempted to capture data on oral health, the workforce and even clinical information regularly (Topping et al., 2005, Council of European Chief Dental Officers, 2011). However, this is only as good as the reliability and accuracy of the recording systems employed. In fair criticism, these processes of data monitoring involve too much extra time allocated from clinical practice. For example in the case of EGOHID, specialised trained 'sentinel dentists' would be calibrated to collect clinical data in a specific way and would need to be part of a primary care network (Topping et al., 2005). This may be challenging to achieve in general practices in the current contract, where associates are tasked with achieving particular UDA targets and this monitoring work may not be financially rewarding.

In England, the most recent surveys, ADHS in 2009 (Steele and O'Sullivan, 2011) and CDHS (2003) (Office of National Statistics, 2004), have been central in discussions regarding health service plans for dentistry (NHS England, 2014a). Both surveys were undertaken ten years after the last, and due to the big gap between significant shifts in oral health were clearly identifiable. There are other surveys that occur more frequently: the National Dental Epidemiology Programme surveys for England (Public Health England, 2012), previously known as the British Association of Community Dentistry Surveys; conducted every two years for five-year and twelve-year-olds, and recently, for the first time, for three-year olds.

The Department of Health in England is encouraging a movement to the use of integrated digital records generally for health, which may prove more useful for regular monitoring of oral health (NHS England, 2014b). At present, no central record system exists to collect general practice data in an integrated manner; however, claims data may be obtained through NHS Business Service Activity (NHS BSA) data, which are freely available through the Freedom of Information Act 2000 (Legislation.gov.uk, 2000). These data are collected by contract performers using patient management systems or FP17 paper records in the contracted clinics. In England, Steele (2009) recommended an increase in the use of innovative electronic patient

management systems to monitor individual patients' health status as they would assist in managing a system of care provision that would ensure continuity and the monitoring of prevention. And as the changes to the contracts are imminent, it would mean digitisation of patient records will be common practice. The opportunity to begin to understand and explore how these types of records could provide more information on changing needs and demand could be crucial to achieving an effective dental care system.

### **2.3.5 Determinants of health and oral health**

#### **2.3.5.1 Introduction**

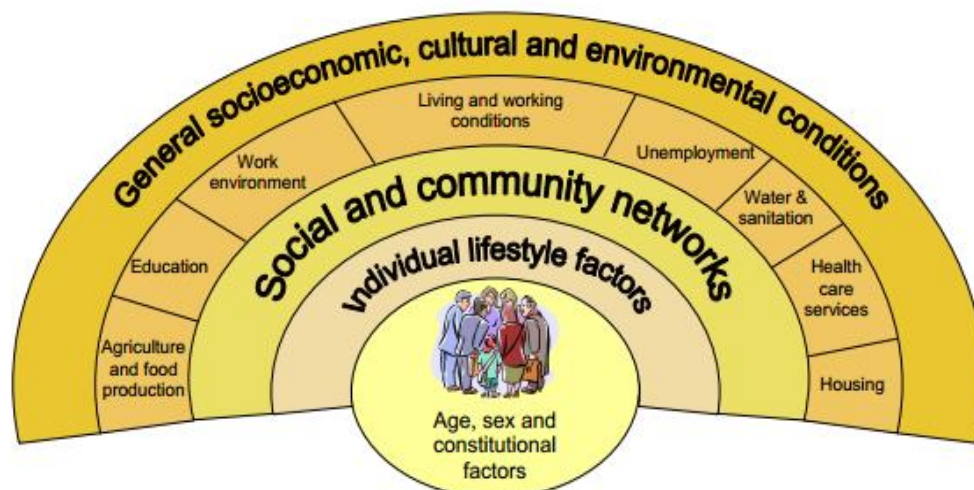
In order to understand how to develop an appropriately skilled health workforce able to meet the general and oral health needs of the population, it is important to examine the factors that influence the state of health. These factors influence demand for health care and subsequently the nature of the health workforce required (Gupta et al., 2003, Zurn et al., 2004). It can be suggested that if all the factors acting upon the state of well-being can be identified, it would be easier to monitor and alter them when necessary for the benefit of the population and plan for appropriate health care. In this section, some of the ways in which the global health community have engaged in tackling these wider issues impacting on health are outlined. The gaps in the strategies are debated and the role of research is outlined.

#### **2.3.5.2 Addressing wider determinants of health and oral health**

Following from the Alma Atta Declaration (World Health Organization, 1978), there has been a global agenda to tackle the impact of social determinants of health, through the promotion of equity in health and social justice (Bryant, 1980). The Commission for Social Determinants of Health (SDH) assembled by the WHO in 2005 (World Health Organization, 2008a), addresses this agenda. The SDH commission proposes that 'social and economic conditions and their effects on people's lives determine their risk of illness and the actions taken to prevent them becoming ill or treat illness when it occurs' (World Health Organization, 2008b).

Models to determine the main factors influencing health became a common way of prioritising and planning for SDHs (Graham, 2004). These models (Dahlgren and Whitehead, 1991, Brunner and Marmot, 1999, Najman, 2001), commonly involved interlinking pathways showing the role of the individual and wider societal factors in health. A widely recognised model by Dahlgren and Whitehead (1991) [Figure 2-1 ] shows in concentric circles the determinants of health. The model does provide a useful guide to identifying areas that could be improved, and may tacitly suggest a hierarchy in determinants; however, they do not quantify the influence of each factor. Graham (2004) argues that these models are not helpful to policy makers as there is no strong impetus to apply impact on one area as opposed to another. He particularly highlights the fact that the influences of these SDHs vary for different groups and it is important

to address the unequal distribution of these determinants between advantaged and disadvantaged groups (Graham, 2004).



**Figure 2-1 Determinants of health**

Source: (Dahlgren and Whitehead, 1991)

Research has shown that there is an evident variation in oral health experience commonly referred to as oral health inequalities (Sheiham et al., 2011, Marmot et al., 2013). As more sophisticated study of various public health problems is beginning to uncover more aspects of the environment impacting on health, appropriate action plans that promote proportionate distribution of health care are proposed (Marmot, 2006, Marmot, 2010, Marmot et al., 2012, Marmot et al., 2013). These plans could however benefit from an understanding of the magnitude of influence of one determinant of health as opposed to another.

In the field of oral health the various factors in the Dahlgren and Whitehead (1991) model have been seen as key in understanding health inequalities. Acting at different points of the Dahlgren and Whitehead (1991) model is considered a useful way to reduce inequalities in health, informed by the action areas of the Ottawa Charter (World Health Organization 1985). The current focus is on reorienting the promotion of dental public health through upstream efforts (Watt, 2007) and health-promoting policy decisions (Department of Health and British

Association for the Study of Community Dentistry, 2007, Department of Health and British Association for the Study of Community Dentistry, 2009, Public Health England et al., 2014). It has been suggested that the most prevalent dental disease - dental caries (Pitts et al., 2011), could benefit most from upstream actions which engage policy that regulates factors such as sugar, which are implicated in the aetiology of caries (Bradshaw and Lynch, 2013, Moynihan and Kelly, 2014, Sheiham and James, 2014). This point relates back to issues raised by Graham (2004), where he suggests that merely identifying factors in the model which impact on a certain area of health is not adequate, and quantifying the level of the problem, based on different factors, provides an opportunity to act on the most appropriate determinant. The sugar debate in caries is a good example as in the last 30 years sugar's effects on dental health have been shown by several studies (Sreebny, 1982, Sheiham, 1983, Sheiham, 1991, Moynihan, 2005, Bradshaw and Lynch, 2013); however, only recently have the conversations about reducing sugar through policy begun to emerge in public debate.

#### **2.3.5.3 Role of research and determining wider determinants of health**

There continue to be more sophisticated methods of research to determine how these wider issues affect several public health problems. This presents an opportunity to learn from other disciplines and to assist in identifying the most effective ways of improving health by understanding and tackling the determinants. For example, dentistry has an opportunity to learn from research of conditions such as obesity, as many risks are shared between dental diseases and chronic diseases (Petersen and Yamamoto, 2005). An example is finding, which have shown that neighbourhood characteristics, such as presence of convenience stores as opposed to supermarkets, have an influence on higher obesity rates in children (Turrell et al., 2004, Whitaker et al., 2013). This may have something to do with the type of food sold, which may include sugary foods and this would also impact on oral health. This is just one example, and it is reasonable to suggest that environmental factors influencing population health needs should be taken into consideration in planning health care and the health workforce appropriately. This is also supported by research that shows there are common risks such as diet, smoking and alcohol for several chronic non-communicable diseases such as diabetes, hypertension, heart disease, dental diseases, obesity (Whitaker et al., 2013, Cane and Butler, 2004, Petersen and Yamamoto, 2005, Pitts et al., 2011, Sheiham and Watt, 2000, Kearns et al., 2014). And

therefore, tackling one of these can act across several groups and improve health equity (Sheiham et al., 2011).

#### **2.3.5.4 Implications of wider determinants on research on skill mix**

More sophisticated studies undertaken to understand the factors influencing health, and the type of care required of the workforce, can provide useful guidance on who may be more at risk of poor health, and which professionals can assist with which skills. It is important to understand who is attending for dental care and what care they receive and how this relates to their social status. It may also identify the patients who could benefit more from preventive care or alternative forms of health promotion, which could be undertaken by DCP members of the dental team. This is in line with the NHS plan which promotes a tailored approach to health care (National Health Service, 2014) and recommendations made by researchers for a whole dental team approach to tackling oral health inequalities (Watt et al., 2014).

## **2.3.6 Meeting oral health needs**

### **2.3.6.1 Introduction**

When policy makers make choices on meeting the health needs of the population, political and ethical factors have an influence on system plans (Roberts et al., 2004). As shown in Section 2.3.5, even following overwhelming evidence implicating sugar in prevalence of caries (Sreebny, 1982, Sheiham, 1983, Sheiham, 1991, Moynihan, 2005, Bradshaw and Lynch, 2013), the guidance and review of policies that may affect the food production industry have been stagnant. Some of this may be influenced by ethical and political positions, which are a part of the wider determinants of health as discussed in the previous section. These positions, if not understood by proponents of public health, may lead to low success of strategies or interventions. In this section some of the ways in which these political and ethical aspects may influence plans to meet oral health needs are examined.

### **2.3.6.2 Ethical positions and their effects on prioritisation**

According to Roberts (2008), three ethical theories are worth considering in health care for their impact on policy decision making; i] utilitarianism, ii] liberalism and iii] communitarianism (Roberts et al., 2004). These ethical theories include economic aspects as well as cultural considerations and are not mutually exclusive. Mack (2004) posits that utilitarianism is a utility-based ideal where the most economically sound strategy promotes well-being. Libertarians have been described as a group that encourages a free market policy and generally supports the negative choice. Roberts et al (2008) describes communitarians as seeking public policy which promotes a certain type of community. Religion is provided as an example of communitarianism (Roberts et al., 2008).

These ethical positions influence prioritisation of resources for health care, which includes staffing. For example in considering utilitarianism as an ethical position, health care planners would plan for services best on value, which can be subjective or objective. On one extreme this approach suggests that what makes individuals happy is ideal. It places value on utility or willingness to buy a commodity. It is an economist's approach and cost-benefit analysis would be used to choose between two options to meeting health needs (Roberts et al., 2008). The issue with this approach is how qualified are individuals to decide what health strategy is best

for them? And this relates to the ways in which the needs are viewed. An example of this would be if cosmetic dentistry were considered most beneficial by the population, and people were willing to spend more for it, the dental contract systems in place within a state-funded care system, like in the UK, would need to place higher value on cosmetic procedures, or if patients stated they preferred dentists to DCPs or vice versa, the state in a solely utilitarian system would prioritise this opinion in their policies.

These standpoints as extreme as they are serve as good examples of the challenging influences on imparting health care strategies for the best population outcomes. On the less extreme spectrum is 'objective utilitarianism', which allows the overall good to be considered before an approach is undertaken but, in a subjective system, planners could conclude that more people value being pain free and therefore place more value on pain relieving emergency dental care, or in the case of appropriate health workers, they would consider that the quality or standard of care is better suited if both professional groups are practicing. Libertarian approaches have been particularly challenging for public health, as they propose a free market policy and this would insist on freedom not to choose health or health insurance, and this has been a challenge for public health proponents. An example is the helmet regulations in the USA as years of battles have seen the regulations to ensure the wearing of bike helmets repealed and subsequently deaths related to this have increased (Jones and Bayer, 2007). On the extreme left, this group could oppose using tax to provide health for the masses (Havighurst, 2006, Roberts et al., 2008). One can see that for such a system universal health coverage would be a challenge for libertarians. In oral health, this has had a significant impact on water fluoridation policy, as this is a population measure aimed at preventing caries; however, for many this marks an infringement on their rights to be 'mass medicated' through their water supply. This has dealt great blows to water fluoridation programmes in the UK (Daly et al., 2013).

What these examples reveal is that, apart from obvious needs, an understanding of ethical underpinning is necessary in order to substantially implement effective changes. This further demonstrates the importance of research to support the prioritisation of needs. This is particularly being supported by the WHO at present, as the global goal is for universal health coverage (World Health Organization, 2013b). It is, however, worth noting that, as earlier



mentioned the different ethical approaches are not mutually exclusive and there are aspects borrowed from each other, and there are moderate positions within these ethical stances and all should be considered collectively. There is a role for research to conduct robust research to support implementation of appropriate health care and workforce plans.

#### **2.3.6.3 Prioritising health needs and equity in England**

In 1980, the Black Report (Black et al., 1980), starkly highlighted inequalities in the UK and recommended a wider remit for health service planning. The report was largely met disparagingly. Those against the recommendations claimed that there was not enough understanding of the mechanisms of poverty and health inequality, and it would be impossible to lend Government services to those needs (Bradshaw, 1994). The response at the time demonstrated that the focus of the day for the politicians appeared to not have been equity in health and they could not see the economic value. Perhaps a somewhat egalitarian liberalism was sought by the Black Report. Egalitarian liberalism suggests society has a special obligation with regard health (Roberts et al., 2008). It may also be argued that the position of detractors of the Black Report adopted a somewhat communitarianist stance, arguing that poverty could not be fully understood by them, perhaps suggesting a community level understanding unknown at Government level.

Since 1980, much has developed, and at present the bio-psychosocial model is currently widely accepted, with the need for equity in health understood (Marmot, 2010). In fact an egalitarian approach to health is present within global health policy as the WHO's (World Health Organization, 2013b) as well as national state health services, which seek equity and excellence (Department of Health, 2010a). The future plan for state funded services proposed a reorientation towards a focus on prevention and patient centred care (National Health Service, 2014).

In dentistry the same principles apply. Gallagher and Wilson (2009) highlighted that change in planning for health care requires taking cognisance of the social, political and cultural context. Particularly to be considered in regard to the dental workforce, is the change in clinical practices, evolution of technology, economic influences related to financing of dental care and the diverse patient base with equally diverse need, and the blurring of professional boundaries

within the dental team (Gallagher and Wilson, 2009). In 2014, similar sentiments have been echoed for the future NHS (NHS England, 2014a). The plan has been shown to also involve early development through the education and training of the dental team to ensure that they are appropriately skilled to perform in the changing climate of need and demand (NHS England, 2014a). Gallagher and Wilson (2009) suggest an approach where the complex alternatives for the future are considered through research techniques such as forecasting and modelling. This is an approach which has been useful when developing a health system where health workers are meeting the different aspects of demand, which include change in need (Birch et al., 2007).

### **2.3.7 Summary**

Section 2.3.2 has defined health and global agenda for general and oral health. The literature has particularly identified the importance of understanding the actual needs of the population and highlighted the relationship between needs and demand on health services, which relates to demand for a health workforce. Demand on services has been shown to be influenced not only by expressed needs, but also by changes in the population, market, technology and societal objectives. This has indicated that there is a benefit in considering all these aspects when planning for health care and for the health workforce. The different policy and ethical positions related to meeting health needs, whether through public health or health workforce plans, have been identified and their impact on the perception of ideal health care and equity in health, especially in systems of universal care such as in England, have been debated. The literature suggests that the planning of both general and dental services requires an understanding of wider determinants of need, and a consideration of these political ethical forces in the process. The role of health research on both the needs and the influences on needs, which may include the environment, has been identified as important for health service and health workforce planners. In the next section the role of primary health care and its role in meeting health needs is addressed

## **2.4 Primary health care**

### **2.4.1 Introduction**

Primary care has a pivotal role in the delivery of the majority of health services, and in ensuring equity in health care access in support of health. It is for this reason that plans to efficiently deliver primary care services must be associated with planning for appropriate capacity and skills within its health workforce. This section of the literature considers the role of primary care and how this impacts on planning for a primary care health workforce, and by so doing highlights the importance of research within the sector.

### **2.4.2 Development of primary care**

Primary care is the first point of contact for individuals seeking services from a health system. It is proposed that countries with stronger primary care systems and policies that promote equity have healthier populations (Starfield, 1991, Macinko et al., 2003, Shi et al., 2003, Starfield et al., 2005). The WHO emphasised a need for competent appropriately skilled health professionals in adequate numbers, distributed proportionately to the population and corresponding to the population's health needs; principally in primary care (World Health Organization, 2013a).

How to achieve this appropriately shaped health workforce in primary care is the question. To do this, there may be some learning to be gained from historical debates that ensued when primary care was launched as the main machinery for health services, as commentators argued that the primary care implementation plans were made with poor reflection on the varied needs in different places (Navarro, 1984, de Kadt, 1982). Mburu (1980) highlighted the dissonance between ideology and reality in the plan to decentralise health care from hospitals to primary care centres and proposed that political machinery in different countries had varied impact, which could propel or obstruct the progression of such plans.

As demonstrated in Section 1.3 it is useful to monitor demand; however, monitoring changes over time and for different sections of society would be a more appropriate approach in terms of the workforce. Mburu (1980) most poignantly reminds readers that recommendations made by Fendall in 1972 to use auxiliaries in under-resourced areas (Fendall, 1972), which had been

ignored even a decade later, and in contrast some continued to support specialisation of medical professionals.

In the present day, as plans to 'scale up' the primary care workforce are made through efforts such as altering education and training (World Health Organization, 2013a), there is an added benefit towards research of actual real life working examples of how scaling up plans are working. This is particularly important for plans to improve skill mix where professional boundaries will be blurred in order to meet the present needs. This calls for purposeful research in the field of primary care.

#### **2.4.2.1 The right staff and right mix in primary care**

The predominant message through the process of primary care development has been to organise health services and the workforce according to the needs and demand presenting to primary care (World Health Organization, 2007a, World Health Organization, 2007b, Dal Poz M.R. et al., 2009, Frenk et al., 2010, World Health Organization, 2013a, World Health Organization and Global Workforce Alliance, 2014). Furthermore, the use of community and auxiliary personnel has been proven to lead to some levels of efficiency in various parts of the world (Goel et al., 2013).

Within England, primary care has risen to a unique, yet challenging position, where every encounter has been proposed to be an opportunity to promote health (Marmot, 2010) and therefore the planning for the health workforce within primary care has centred on ensuring the staff mix has a balanced view on delivery of health promotion (Department of Health, 2004b, Department of Health, 2007a). How to ensure that these goals are achieved is the question. Educating the right primary care workforce and ensuring local needs are understood has been a constituent of part of this plan in the last decade (Darzi, 2008). Part of this has involved a call for more team based models of care and collaborative practice; however, it has been noted that few data exist on the feasibility of these models and more research is required (Grover and Niecko-Najjum, 2013). Commentators such as Lehman et al (2009) argue that 'a clear comprehensive and integrated reconfiguration of health teams', 'changed scopes of practice and regulatory frameworks' and enhanced training infrastructure would improve chances of success for workforce strategies such as skill mix in primary care. They propose that all these

areas require support of advanced research (Lehmann et al., 2009). This is particularly relevant as it is evident that research in primary care is limited.

### **2.4.3 Access to primary care services in England**

#### **2.4.3.1 Introduction**

As plans are configured to ensure the workforce and policy within primary care are shaped to ensure that the right mix of health workers are available to cope with the needs and demands of the population globally, it is relevant to consider the local situation in England where this research is focussed, and further reflect on the premise that service capacity through health workers and availability through primary health care centres does not denote service use. This draws parallels to the earlier topic on wider determinants on health in section 2.3.5, where it becomes clear that there is complexity in the process in which individuals obtain the care they need to achieve health. In this section the structure of primary care service in England is outlined, aspects of access to primary care are deliberated and how this impacts on health workforce structuring.

#### **2.4.3.2 Primary care in England**

Primary care in England is provided through both the private sector and the National Health Service (NHS) state funded care; predominately the latter, albeit that the private sector is increasing. Since early in the last decade, the NHS vision for health care has parallels with global movements to promote community health and equity through improvements in primary health care services (Department of Health, 2005b, Darzi, 2008, World Health Organization, 2008c). The UK NHS service has been described as one of the most developed primary care systems in the industrialised world (The European Observatory on Health Systems and Policies, 1999). However, there have been challenges to access to NHS services in the past and this has led to concerted efforts to enforce primary care policy and workforce plans that improve capacity and meet the needs of the population (Department of Health, 2007a, Department of Health, 2008a).

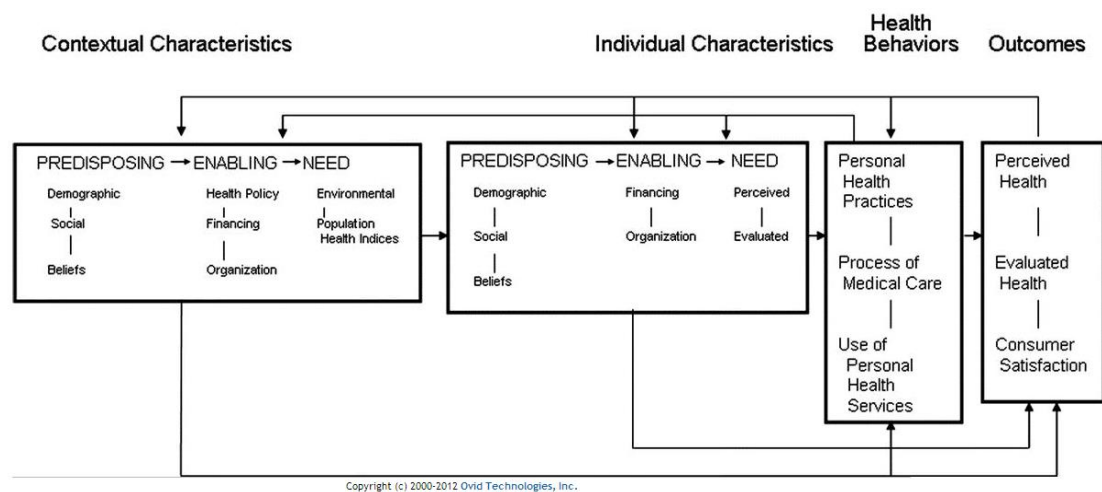
It would appear that access to primary care is a focal part of the new NHS agenda as evidenced by a £50 million challenge fund recently dedicated to improving access to primary care (Department of Health, 2014b). The workforce in primary care is also a key part of future NHS plans as indicated by the policy document *'Transforming Primary Care: Safe, Proactive, Personalised Care for those who need it most'* (Department of Health, 2014b), which outlines

that in order to provide care to those who need it the most, there will be a need for the right training for health workers to ensure that they can improve their skills to meet people's changing needs, while working across traditional boundaries. Such policy positions are encouraging, and evidence does suggest that policies that promote equity in access to primary care improve population health (Starfield et al., 2005). It is further encouraging that recommendations to ensure that policy which favours proper use of skills is adopted as this mitigates the common political challenges for the advancement of teamwork in health care (Green et al., 2007).

#### **2.4.3.3 Factors influencing access**

Access is an important facet in determining demand, as it can suppress or increase demand for care. It is important to acknowledge that access to health services has been shown to be more complex than ensuring a certain number of primary care centres or clinicians are available (Gulliford and Morgan, 2003, Milsom et al., 2009, Paley et al., 2009, Borreani et al., 2010, Currie et al., 2012, Harris, 2013). According to Adday and Andersen (1975), access to any form of health care should be regarded as whether those in need of services get into the system (Aday and Andersen, 1975). Gulliford and Morgan (2003) propose that 'having access' does not necessarily denote; 'gaining access'. This is because having access could suggest that there are services; however, whether individuals who require these service 'gain' entrance to the service is more important (Gulliford and Morgan, 2003).

The updated Anderson's Behaviour model for use of health services (Andersen, 2008), developed for over 50 years, gives useful insight into identified contextual and individual factors that contribute to health access. **Figure 2-2** is the model and it highlights the interplay between contextual characteristics and individual characteristics including health behaviours. Baker (2009) confirmed the applicability of Andersen's model in understanding the role of contextual factors in oral health practices and service utilization as well as perceived oral health outcomes. It can be argued that reflection upon all these factors, in combination with strong policy, may be the more ideal approach to improving access to a variety of health services.



Source: © 2000-2012 Ovid Technologies Inc

**Figure 2-2 Modified Andersons Behaviour Model for use of health services**

Babitsch et al. (2012) have recommended that researchers undertake more complex statistical analysis for investigating access. They propose that this will facilitate a deeper understanding of the relationships between the variables in the model and patient access behaviours (Babitsch et al., 2012). Perhaps this is the recognition of the variations in health by different populations, especially in view of the inequity in access to health care. Certainly, more models pertaining to access behaviour of vulnerable groups and diseases are needed (Gelberg et al., 2000, Dixon-Woods et al., 2006). And as targeted programmes through primary care are growing in number (Nunn et al., 2007, NHS Scotland, 2011), there are opportunities to maximise on skills of all professionals available, in order to improve service availability and ensure services reach the community (Centre for Workforce Intelligence, 2014b).

#### 2.4.4 Summary

This section has identified primary care services as the point of first contact for the majority of individuals who seek health care. Understanding the demand for services and the capacity within primary care to meet the demand is a major challenge for the success of primary care services. Appropriate planning for health workers is a key strategy employed towards mitigating these challenges. It is, however, acknowledged that this lies within regulatory, political, cultural and political debates and therefore strategies informed by rigorous research are more likely to yield success of primary care and the primary care workforce.



## **2.5 Primary care dental services in England**

### **2.5.1 Introduction**

The literature has so far highlighted that there are changes in the needs and demands of the population and this has implications for primary care. This section explores the current premise for the provision of dental services in England and the pending reforms.

### **2.5.2 How dental services are provided in England**

Dentistry is a £5.73 billion market in the UK, and NHS services account for 58% of the market worth; with the remainder (48%) provided privately (Office of Fair Trading, 2012); however, the volume of patients seen in the NHS is higher as it cares for the majority of children and adults (Office of National Statistics, 2004, Steele and O'Sullivan, 2011). The NHS in England spends £3.4 billion per year on primary and secondary care dental services, with over 1 million patient contacts with NHS dental services in England each week (NHS England, 2014a). With this sizeable resource associated with the provision of dentistry, productive and financially astute operating models for NHS dentistry are encouraged, but conversely under-researched (Holmes et al., 2011, Brocklehurst et al., 2013).

The General Dental Services (GDS) provides the majority of care within primary care. Community Dental Services (CDS) are a small part of primary dental care, having evolved from being a child-only service to a service complementary to the General Dental Services, including 'access functions' together with specialist-led services including special care and paediatric dentistry (House of Commons Health Committee, 2008, National Commissioning Board, 2013). Hospital Dental Services are responsible for secondary care, and together with universities support undergraduate and postgraduate teaching (National Commissioning Board, 2013). This next section provides a preamble to the critique of NHS primary dental care organisational changes, by highlighting the transformation in NHS primary dental care services structure through the years.

### **2.5.3 NHS primary dental care: the transformation**

When NHS primary dental care was established in 1948, oral health needs in the UK were high. General dental practitioners entered a national contract, with payment on a fee-for-item-of-service basis and no upper limit to practitioner earnings (Nuffield Foundation, 1993, Downer and Drugan, 2007, Tickle, 2012, Department of Health, 2015). NHS dentistry was initially provided at no cost to the patient; however, because of high demand for services, and therefore costs to the NHS, patient charges were introduced for dentures in 1951 (Tickle, 2012). The payment system incentivised clinical activity to treat disease and replace missing teeth.

Over the past two and a half decades the change in oral health needs of the population has led the NHS seek ways of introducing new more efficient contracts for dental care (Wilson and Gelbier, 2014). Due to this and professional and public concerns two national reviews have been undertaken (Bloomfield, 1992, Steele, 2009). These have led to a range of pilot schemes, to test new ways of working and remuneration.

The 1990 contract encouraged continuity of care; it involved patient registration, encouraged continuity of care, the requirement to provide emergency care, treatment plans and information leaflets for patients (Bloomfield, 1992). Remuneration was a mixture of capitation and fee per item, which differed between children and adults (Department of Health, 2015). In addition, co-payments increased and it was believed that capitation-based contracts would encourage preventive services (Nuffield Foundation, 1993). The fees were calculated according to what was considered the average earnings of a dentist. This NHS contract in the 1990s led to resistance from dentists who felt that the contract would reduce their earnings and resulted in an increase in the number of privately treated patients (Downer and Drugan, 2007).

There has been a series of different pilot schemes to test new ways of remunerating dentists in line with changing oral health needs and demands, starting with Personal Dental Service (PDS) pilot contracts scheme in 1997, which, following evaluation, were suggested to improve capacity and needs based care using a team approach (Goodwin et al., 2003). In 2006 reforms moved to local commissioning of health care introducing an untested activity based contract involving Units of Dental Activity without any element of capitation. The contracts were national but locally agreed with Primary Care Trusts and financially capped on the basis of historical earnings.

The UDA system depends on the type of work undertaken. A dentist is contracted by a commissioning authority (Primary Care Trust before April 2013) to do a set number of UDAs and dentists have to be within 4% of their targets (Professional Dental Services, 2010). This system is specific to England and was introduced as part of major reforms in April 2006 (Milsom et al., 2008). UDAs are obtained as a result of the course of care a patient received. If dentists don't achieve their contracted number of UDAs they are financially penalised (Professional Dental Services, 2010). If dentists do more than their contracted number of UDAs they do not get paid additional money. There are four categories in courses of care which are used to calculate UDA value for treatment rendered. **Table 2-1** shows the 4 band categories. The value of a UDA is variable, dependent upon contract negotiations with the PCT or Local Area Team, one UDA might be worth anywhere between £15 and £25, but can be more than this or less. The actual UDA value varies according to the dentist local PCT contract and the amount of work previously carried out by the dentist before the new contract was implemented (Professional Dental Services, 2010).

**Table 2-1 NHS treatment bands**

Course of care	Definition	UDA value
<b>Band 1 excluding urgent treatment</b>	Diagnosis, treatment planning and maintenance Examination, x-rays, scale and polish, preventative work, for example an assessment of a patient's oral health, minor changes to dentures.	1 UDA
<b>Band 1 urgent treatment only</b>	Band 1 and Examination, x-rays, dressings. Re-cementing crowns which have become loose, up to two tooth extractions and one filling.	1.2 UDAs
<b>Band 2</b>	Any in band 1 plus, simple treatment, for example tooth restorations (including root canal treatment), tooth extractions and periodontal (gum) treatment	3 UDAs
<b>Band 3</b>	Complex treatment that includes a laboratory element, for example bridges, crowns and dentures (excludes mouth guards).	12 UDAs

Source: Note: NHS payment system in England from April 2006. For further information see NHS Choices – <http://www.nhs.uk/nhsengland/aboutnhservices/dentists/pages/nhs-dental-charges.aspx> .

The PDS plus contracts were introduced and these were 'locally sensitive' alongside GDS contracts. Following this in 2006, more accountability from PCTs for the contracts was instituted (Milsom et al., 2008). These contracts specify payments through a 'three-arm system' of services. First, is by treatment activity (**Table 2-1**), which is calculated by a 'Unit of Dental Activity' undertaken by an NHS dental service provider. Second, access is calculated according to the number of new and unique patients attending the practice (these are patients who have not attended the practice in the preceding 24 months). Third, through performance, which is measured by key performance indicators (KPIs) e.g. ascertaining smoking status in order to signpost to smoking cessation services, etc. (UK Parliament, 2005). There are national and local KPIs introduced to measure and remunerate performance.

In April 2013, dental commissioning moved to NHS England and all contracts are now centrally commissioned (but locally negotiated) (Department of Health, 2010b). This is part of the wider NHS changes. Piloting continues post Steele (2009) (Department of Health, 2014a). The new contract has been testing a new care pathway and capitation system of payment and will be implemented. The next phase of pilots which involves 'prototypes' of the new contract have just been announced and their purpose is to develop a robust model fit for roll-out nationally (Department of Health, 2015), in line with the general philosophy of the NHS (NHS England, 2014a, National Health Service, 2014).

#### **2.5.4 Summary**

The majority of dental services are undertaken in NHS primary dental care. NHS primary dental services are managed through a contract system with independent general dental practitioners. Through the years the contract has undergone minor and major reforms to enhance the quality and performance of the system for the benefit of the patients. Currently a major reform is pending and this system is geared to alter to meet the changing needs of the population. There is a role envisioned for DCPs and it is to this point that the potential contributions of DCPs should be understood.

## **2.6 Drivers of change**

### **2.6.1 Introduction**

There is a significant organisational reform under way and proposed changes are purposeful in their aims, as they attempt to aid better provision of care using different payment strategies and workflow organisation. In this section, the process of health care reform and the actual drivers of reform in the current English primary dental care system are explored. This leads into conversations around the role of the whole dental team in primary dental care reforms.

### **2.6.2 The process of health system reform**

The changes proposed for dental services in England include altering the practice of health workers in order to improve the performance of the health sector, and this should be viewed as an 'organisational health reform measure' (Roberts et al., 2004). However, like all types of reform, it requires a significant, purposeful effort (Scott et al., 2003). To be successful, Roberts et al. (2004) suggested a strategic reform process, based on honest means-ends analysis of what is likely to happen in a particular national context, and ideally, this would imply a critical analysis and reflection before implementation; view supported by Nuffield (2012) in their report '*Reforming payment for health care in Europe to achieve better value*'. This is relevant to this study, as it describes an attempt to test alternative approaches to the organisation of skill mix used in primary care. In many occasions, such critical analysis and reflection before implementation is overlooked, and the result can be a lack of appropriate prediction of outcomes, jeopardising the success of the reform measure (Hunter, 1994).

Hunter (1994) suggests that often the sophisticated subtleties of managing the changes of reform are a failing of politicians and policy makers, who are keen to leave their imprint in an area of policy. This idea can find examples in present day politics, where health care system reform is a common target for newly installed political entities; demonstrated by policies such as 'Modernising the NHS' from the Labour Government (Department of Health, 2000b), 'The Health and Social Care reform' from the Conservative party (Department of Health, 2010a), as well as parts of the world like the US, 'The Patient Protection and Affordable Care Act' Democratic party USA (Office of the Legislative Counsel, 2010). The subject of health is undoubtedly entangled in politics, and in the UK where the NHS accounts for a large proportion

of the fiscal budget, political accountability remains attached to how it is organised. There are, however, opportunities for researchers and academics to contribute to critical analysis of health sector changes, thereby improving chances of success (Hunter, 1994, Popay and Williams, 1994).

The success of a proposed change in organisation could be influenced by a multitude of factors. According to Scott et al. (2003), the cultural organisation of a system could have considerable influence and lead to either functional or dysfunctional outcomes (Scott et al., 2003). These cultural elements are the non-documented operating structures, developed consciously or unconsciously by those involved in the system and, without a clear understanding of these, instituting an organisational shift can be challenging. The reconfiguring of the relationships between users, providers and managers can result in varied and dynamic uncertain behaviour by the actors (Hunter, 1994). An example of uncertainty of reform can be demonstrated in the case of payment systems; where a change in behaviour of professionals could occur to defend their incomes, if a new payment scheme is in place (Gilman, 2000, Yin et al., 2013, Nuffield Trust, 2012).

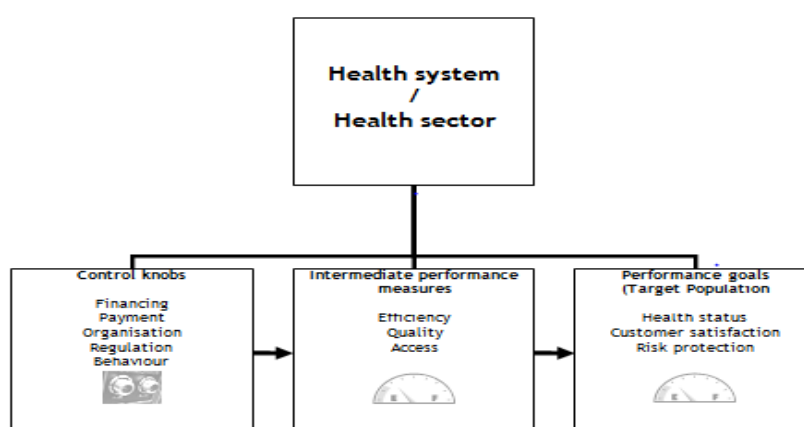
In the case of fee-per-item payment systems in NHS dental services in the 1990s, dentists found incentive in a 'drill and fill' approach to maximise on profit (Birch, 1988, Bloomfield, 1992, Tickle et al., 2011). Later when the contract system was changed, the number of procedures declined. Harris et al. (2014), suggest that it is important to consider inter-related social networks, organisational forms, labour markets, political policies and institutions when instituting reforms such as contract changes (Harris et al., 2014). The overarching message is to approach reform sequentially through process and research/evaluation in order to have a chance of achieving success.

### 2.6.3 Assessing drivers of change

The 'control knob' has been used by Roberts et al (2008), as a metaphor to describe an aspect of a health sector that can be altered to influence the health system performance; these are the main points of health reform. See **Table 2-2**. According to Roberts et al (2008), these five system knobs, allow diagnostic processes of the likely result of reforms, and influence the development of substantive policies to achieve better performance. The performance indicators are three namely 'access', 'quality' and 'efficiency' See **Figure 2-3**

**Table 2-2 Control knobs (health sector influences) and definitions**

Control (system influence)	Definition
Financing	Mechanisms for raising money to pay for health services e.g direct payments by patient, co-payment systems, taxes etc
Payment	Methods for transferring money to health care providers fees, capitation etc
Organisation	Mechanisms reformers use to affect the mix of providers in health sectors, in regard to roles and functions and internal operations.
Regulation	Use of coercion by state to alter behaviour of actors in health system
Behaviour	Includes efforts to influence individual patient and provider in relation to health



(Source: Roberts et al, 2008)

**Figure 2-3 Control knobs of health sector reform and performance indicators**

During health reform, significant changes usually require the use of more than one knob. Adjustment of one knob would often lead to changes in other control knobs (Roberts et al., 2004). These factors, outlined as control knobs, are not exhaustive of the influences on the health sector, as social and cultural influences are known to have significant influence on health (Marmot, 2010). In assessing the intermediate performance indicators of a health system or reform efficiency, quality and access are commonly the central drivers of reform and have been considered as follows:

#### **2.6.3.1 Efficiency**

This has been a central focus of many changes or reform measures in health services. It is measured in different ways, based on inputs and outputs. One of the main ways of considering efficiency is through technical efficiency, which refers to a situation where services provided at a minimum cost or resources are maximised (Roberts et al., 2004, Guinness and Wiseman, 2011). In health system reforms currently under way in the wider NHS, efficiency that maximises on resource and creates equity of outcomes is a key driver (Department of Health, 2010a, National Health Service, 2014).

#### **2.6.3.2 Quality**

Quality, which is also a performance indicator, is a function of process and structure of the organisation. According to Donabedian's theory of quality, structure and process are considered influences to outcomes (Donabedian, 1982). In many cases quality is maintained through evidence based guidelines of practice. For example, in England the National Institute of Clinical Excellence (NICE) provides considerable useful guidance on how to maintain quality based on evidence such as dental recall guidance (National Institute for Clinical Excellence, 2004). And the five-year plan for the NHS provides guidance of how this can be achieved and monitored (National Health Service, 2014).

#### **2.6.3.3 Access**

Access, as an intermediate indicator, has many facets but primarily when discussed in health reform, the reference is to the utilisation of health services. As mentioned in Section 2.4.3 availability of services does not necessarily lead to access of services (Gulliford and Morgan, 2003), and the factors contributing to the utilisation of dental services as outlined by Andersen



and Newman are multifaceted (Andersen and Newman, 1973), and should be considered as such as highlighted in the NHS plan (National Health Service, 2014).

#### **2.6.4 Health workers and performance of a health system**

When considering the role of human resources for health, i.e. the health workers in the health system, their performance and therefore the efficiency of the system are in question. A closer look at efficiency as a performance measure suggests that organisational reforms such as focusing on skill mix and teamwork are the 'inputs' to produce desired 'outputs'. There are four types of efficiency: technical efficiency mentioned earlier, where the idea is that in order to produce more of an output one needs less inputs (Roberts et al., 2004). Another definition is that in this type of efficiency there is 'minimum wastage' (Guinness and Wiseman, 2011). Economic efficiency has been equated to minimum cost for outputs, while *pareto efficiency* is a system that assumes perfect allocation of resource, where for one to gain someone must lose (Guinness and Wiseman, 2011). The final type of efficiency and perhaps the most suitably applicable to health systems is 'allocative efficiency' (Roberts et al. 2004). This refers to producing the right collection of outputs to match demands e.g. more prevention, less restoration etc. While considering a technically efficient use of inputs (value for money).

There has been limited research in relation to the economic and technical efficiency of the dental team (Wang, 1994, Linna et al., 2003). This involved considering minimum inputs to obtain maximum outputs. What is usually unclear is the definition of outputs in primary dental care, which may vary (Harris and Sun, 2012a). It can be argued that this would be based on the policy priority, whether financial savings or improved patient outcomes.

When considering hygienists and hygiene-therapists for their contribution to efficiency of health systems, studies have focussed on cost saving, suggesting that it would be small, if any at all through the use of their skills (Linna et al., 2003, Beazoglou et al., 2012). This type of study provides a narrow economic view of their contribution and ignores the overall impact of their contributions. Harris and Sun (2012), identified a wider view of efficiency in general dental practices, which was associated with the use of hygiene-therapists. Their findings suggested that dental practitioners saw efficiency of skill mix having association with not only income but also patient satisfaction and health improvement (Harris and Sun 2012).

Ideally, to outline the potential for skill mix it is necessary to critically examine the theories that are related to efficiency of the dental team. These theories of efficiency should take in to account the meeting of patient needs(Liu, 2003). Liu (2003) describes this as a global goal of efficiency where one considers the needs of the recipients of care. Undoubtedly economic aspects of service provision are important in terms of finite resources, but proper economic perspective requires assessing health care efficiency in terms of health outcomes, and also the complex nature of health service production (Peacock et al., 2001). In addition, the complex organisational logics that exist in NHS dental services and the engagement of providers with the contract are further elements for consideration (Harris and Holt, 2013, Harris et al., 2014). Considering models of skill mix, describing the needs of the population remains a central part of a public health approach to meeting need and demand, together with delivering evidence based practice for better patient outcomes.

## **2.6.5 Drivers of change to NHS Dentistry**

### **2.6.5.1 Introduction**

In defining the drivers for change in NHS dentistry, all three performance indicators: quality, efficiency and access have been commonly discussed, directly or indirectly. This section will debate the implications of these drivers on services and the use of the whole dental team in primary care. First, an overview of the main problems is presented within key documents and this is accompanied by a framework demonstrating where each driver lies within the three intermediate performance indicators. This is followed by a debate on each key driver identified.

### **2.6.5.2 Overview of drivers of change**

The Steele report highlighted several issues around quality and efficiency of dental service commissioning and care, with particular consideration of the changing oral health profile of the population (Steele, 2009). Local commissioning, which was instituted in the 2006 contracts, showed variations in quality across regions and this was highlighted as a concern (Steele, 2009, Harris and Bridgman, 2010). Access and quality of NHS dental services also remained a long-standing issue (Department of Health, 2008b). Comments in regard to the potential increasing in demand for particular dental services for different sections of the society and change in the nature of skill required have also kept the conversation about skill mix and optimisation of skills of DCP at the frontline (Gallagher and Wilson, 2009). In **Figure 2-4** key drivers of change mentioned in various documents are placed within a framework that includes within them Roberts et al. (2008) intermediate performance indicators of health care reform.



**Figure 2-4 Drivers of change to NHS dental services using intermediate performance indicators**

#### **2.6.5.3 Drivers of change: 1: Changing oral health needs**

Marked improvements in oral health, including more children being caries free and increased tooth retention amongst older adults are some of the reasons for which primary care services need to change approach to maintain health and consider planning for time for complex care (Watt et al., 2013, NHS England, 2014a). Furthermore, the population is expanding and ageing (Office of National Statistics, 2015) thus increasing the volume of need. The evidence base (Department of Health and British Association for the Study of Community Dentistry, 2007, Department of Health and British Association for the Study of Community Dentistry, 2009, Public Health England et al., 2014), on prevention highlights that different groups require different care in order to maintain health. In this section, notable trends from oral health surveys and their implications for practice are considered. This provides a picture of the roles open to the future dental workforce in England. The review of these survey findings also provides insight

on the wider issues impacting on oral health status and service attendance, giving foundation for a need to consider all these aspects when planning services and the workforce.

#### 2.6.5.3.1 Children's oral health in England

The most recent oral health surveys for children in England are the epidemiological surveys conducted by the British Association of Community Dentists (BASCD) and Public Health England (Public Health England, 2012). These surveys are conducted every two years. There are surveys for 3-, 5- and 12-year-olds. Only the last two surveys (2009; 2012), are comparable as there has been a shift in consent for participants with an 'opt in' rather than 'opt out' approach (NHS Dental Epidemiology Programme for England, 2009, Public Health England, 2012). Having plateaued for several decades, caries prevalence in 5-year-olds appears to be falling again to a mean (NHS England, 2014a, Public Health England, 2013a). Among children who had dental caries in the survey population the mean dmft (Decayed Missing Filled Teeth: primary teeth) was 3.38 (Public Health England, 2013a) and it was more likely for those requiring restorative care, that only simple treatments would be needed. This is particularly significant in terms of who can provide care, as researchers have argued for the potential for significant contributions from DCPs in terms of routine care (Hay and Batchelor, 1993, Ireland, 1997, Evans et al., 2007, Bailit et al., 2012). It is likely that the skills of DCPs are more favourable to the change in treatment need presenting in this age group.

In the last 2006/2007 survey of 12-year-olds, improvement in overall mean DMFT (Decayed Missing and Filled Teeth) for England and Wales since the 2000/2001 remained constant, while geographic variation in oral health was marked at both the local and national levels.

What remained common in both 5-year-olds and 12-year-olds were the marked geographical variations and inequalities in children's dental health. Higher dmft scores are still associated with higher indices of multiple deprivations (Public Health England, 2012, Public Health England, 2013a). What this demonstrates is the need for more conscious efforts to create equity (Marmot, 2010). Watt et al. (2013) has proposed a whole dental team approach to reduce the inequalities that exist in oral health and includes considering the use of DCPs in extended roles that are involved with health promotion.

The last decennial UK Child Dental Health Survey (CDHS) in 2003 involved a representative sample of children at the ages of five, eight, twelve and fifteen. A total of 12,658 children were sampled and 10,386 examined, achieving an 82% response rate (Office of National Statistics, 2004). At that time, now over 10 years ago, it showed that the mean DMFT (Decayed Missing Filled Teeth: adult teeth) among 12-year-olds was 0.7, the lowest since records were first established in 1973 (Office of National Statistics, 2004). This indicated that these age groups in England had the best dental health in their age group in Europe. Also revealed, was that 57% of five year olds, 62% of 12-year-olds and 50% of 15-year-olds in the UK had never experienced any decay or needed dental tooth restorations (Office of National Statistics, 2004). This picture shows a similar trend to the BASCD and PHE surveys (NHS England, 2014a).

All these surveys suggest a clear social gradient with children from lower social groups having worse oral health (Office of National Statistics, 2004) (Public Health England, 2013a). These survey findings suggest that there is a need to be ready to provide routine care for children and to also facilitate effective health promotion to secure and/or maintain oral health. The plans with the new dental contract have involved capitation arrangements that have tested weighting based on deprivation in a move to address higher levels of need (Department of Health, 2010b). However, it may have been useful to consider how DCPs can be involved in children's care and preventive care as it seems that they are equipped with the necessary skill for the type of expressed need from these patient groups (General Dental Council, 2013b).

#### 2.6.5.3.2 Adults' oral health in England

The most recent findings on the state of oral health of adults in the UK, ex-Scotland (Steele and O'Sullivan, 2011), detailed a changing oral health profile (Steele et al., 2012). Eight indicators of oral health were reported, these included: oral health and function, disease and related disorders, urgent conditions, complexity and maintenance, preventative behaviours and risks to oral health, outcome and impact and finally, access to dental care (Steele and O'Sullivan, 2011). The implication of these most recent findings has been a call for greater involvement of the whole dental team in meeting these changing needs (Watt et al., 2013).

The number of dentate adults (adults with some or all of their teeth) in the population was 94% in the ADHS (2009), which is an increase from 88% in 1998 (Steele et al., 2012). The number of

sound and untreated teeth among dentate adults also increased; from 16.9% in 1998 to 18% in 2009. Ninety-six per cent of dentate adults aged 16 to 24 years and 68 per cent of those aged 35 to 44 years had 18 or more sound and untreated teeth, compared with 35 per cent of dentate adults aged 45 to 54 and only five per cent of dentate adults aged 75 to 84 years. This still suggests that younger people retain sound teeth longer and a good proportion of older people still have sound teeth, whilst most adults experience tooth decay at some stage in their lives. Decay on root surfaces was uncommon in younger adults, but amongst adults aged 65 years and over, an average of 10.6 teeth were vulnerable, and a third had root caries (Steele and O'Sullivan, 2011). This suggests that although older people are retaining their teeth longer they are vulnerable to complex care needs, such as managing root caries and a requirement for endodontic treatments. This may lead to the need for more time spent by dentists 'whose scope of practice' involves complex care.

Complexity of treatment received by the dentate population in the survey was measured under a new complexity score [0-8] where zero indicates low complexity (Steele and O'Sullivan, 2011). Thirty-seven per cent of dentate adults had a complexity score of zero whilst only 3% of dental adults scored *five* or more, indicating that 3% of the population had complex treatment needs. Eighty-five per cent of adults had at least one restored tooth and 84% had at least one crown. People under the age of 45 years were less likely to have tooth restorations and 16-24 year olds had the least number of tooth restorations (Steele and O'Sullivan, 2011). The implication is that clinical time would increase as complex care would require more time (Watt et al., 2013).

Geographical variations in oral health status were seen in the ADHS, revealing a similar pattern to children's surveys of oral health and inequalities (Office of National Statistics 2003, Steele and O'Sullivan 2011). One in ten of the English population had excellent oral health however, this varied geographically with 4% in West Midlands having excellent health compared to 20% in East of England (Steele et al., 2012). Geographical variations in oral health status are encompassed in inequalities in health, which stakeholders are considering equally with other plans to tackle inequality.

Apart from pathological tooth-wear, almost all other survey indicators showed improvements when compared to the previous ADHS. Tooth wear cases increased markedly from 66% of

dentate adults having tooth wear in the previous ADHS to 70% in 2009 ADHS. In terms of severity, the proportion of moderate tooth wear increased from 11% in 1998 to 15% in 2009 (Steele and O'Sullivan, 2011). This relates to diet, e.g. fizzy drinks and again in reference to these wider issues impacting on dental health, there is room for health promotion, which could be easily undertaken by DCPs.

#### **2.6.5.4 Drivers of change: 2: The payment system**

The second driver of change has been the shortfall in the current reward for units of dental activity in primary dental care contracts, which has taken sharp criticism for its lack of incentives for prevention and inflexibility of the role of therapists within an activity based contract (Ward, 2006). It has been proposed that the current system rewards complexity of care at a higher UDA value than prevention without intervention (Bullock and Firmstone, 2011). An explanation for the inflexibility in consideration of DCPs roles in the current payment system, can be traced back to the pilot stages of PDS contracts where DCPs roles were not commentators who suggested that PDS practice dentists failed to share feedback about practice developments with the DCPs (Goodwin et al., 2003, Ward, 2006). This could be criticism on reform practice, where one system factor (payment) is considered in isolation of another; organisation. Considering at the time, a call for optimisation of roles of DCPs had been widely discussed since 1993 (Nuffield Foundation, 1993), and 'Options for Change' back in 2002 (Department of Health, 2002a). It would have been wise to find ways in the contract to use DCPs or consider awarding them for NHS activity. Responsively, in the recent pilots purposeful evaluations around skill mix have been undertaken (Department of Health, 2014a).

#### **2.6.5.5 Drivers of change 3: Under-utilisation of skills of the dental team**

Under-utilisation of skill of DCPs is listed as a driver because several authors have recommended adjustments of the 'organisation' and 'regulation' in support for more autonomy of DCPs in order to reap the reward of skill mix within current or future dental contracts (Department of Health, 2002a, Gallagher and Wilson, 2009, Turner et al., 2011, Brocklehurst and Tickle, 2011a, Brocklehurst et al., 2013). Surveys have repeatedly indicated that DCPs are not fully utilised (Gibbons et al., 2000, Jones et al., 2007b, Turner et al., 2011). The directive by the GDC allowing direct access to DCPs for patients, without prescription by a dentist, was announced in early 2013 (General Dental Council, 2013a) and is a response to that call. Unlike



the pending new national contract, which has been under pilot for over two years (Department of Health, 2010b), direct access appeared to mainly involve consultations between stakeholders and the General Dental Council (British Dental Association, 2012), and the lack of direct access having been highlighted by the Office of Fair Trading as 'dampening competition in the dentistry market, reducing innovation, limiting patient choice and leading to inefficient use of resources in the provision of dental treatment' (Office of Fair Trading, 2012).

For policies such as 'direct access' (General Dental Council, 2013a) that have been rolled out, policy makers and providers are reliant on research evidence to help predict outcomes. The impact of direct access is unclear; a review by Turner et al. (2013) suggests that behaviour and organisational issues such as over-referral are likely outcomes. And there are definitely cross-regulatory issues worth consideration such as the lack of performer contracts for DCPs to enable them to see patients directly under the NHS, together with limitations on prescription of certain drugs (Wake, 2014). The message is that further research into how DCPs can fit into the delivery of primary care is necessary, together with policy change to enable skills to be tested fully.

#### **2.6.5.6 Drivers of change 4: Disparities in access**

Having established the focus on reforming primary dental care by improving prevention and maintaining health, there still needs to be a considerable importance placed on equity in access. Improved access is a primary objective for the Department of Health (Department of Health, 2015). And evaluating equity in access to primary dental care has been proposed to be easier than in access to general health services (Gulliford and Morgan, 2003). According to Gibson (2003), this is because access in dentistry is defined in relation to whether individuals have visited a dentist within a minimum set period, considered necessary for maintenance of good oral health, as opposed to general services where waiting times or ability to obtain appointments when in need of services would constitute service access. Currently this is defined as within 24 months for adults and 12 months for children under 18 years (National Institute for Clinical Excellence, 2004). More recently, Harris (2013) proposes the measuring of an 'initial utilisation' separately from 'continued utilisation'. This is reflecting modern approaches which distinguish 'entry access' (gaining entry to the dental care system), from the process of gaining access to higher levels of care (Harris, 2013). This is similar to access as defined by

Gulliford and Morgan (2003), (Section 2.4.3). These suggestions would allow for measurement of the supply or the equity of access as they principally account for actual engagement with the health service.

Investigation of access to NHS dentistry, ADHS (2009), suggested that of the 58% of adults in the survey who attempted to access NHS care, 92% were successful; of these just over half (52%) had also visited a dental hygienist or therapist (Steele and O'Sullivan, 2011). Twenty-six percent of those who accessed dental services stated that the type of dental treatment they opted for in the past had been affected by cost and this delayed treatment (Steele and O'Sullivan, 2011), reinforcing evidence that cost is a barrier to dental service access (Gibson, 2003, Borreani et al., 2010, Borreani et al., 2009, Borreani et al., 2008).

It is, however, important to consider whether the encounter with services is worthwhile, as merely gaining access does not denote substantial benefit. Marmot (2010), proposes equity but also insists that every encounter with services should count for health promotion, and this should start at an early age. In a positive way the current premise of attendance to dental services based guidelines from the National Institute of Clinical Excellence (National Institute for health and Clinical Excellence, 2004), promotes this, by not only stipulating the recall guidance of patients based on oral health risk but also providing evidence based information on the nature of preventive care these patients should receive. This guidance is important in two ways: first, it ensures that health promotion occurs when patients engage with the system and secondly it provides grounding to plan for staffing and skills required if guidance are followed.

It can be proposed that this approach also gives a sense of the nature of actual need based on how accessible the service is; i.e. elimination of known barriers to access like cost and capacity (Feldstein, 1999). Economists would support this approach, as a measure of utility can be accounted for and considered for its benefit, especially when managing finite resource is a target (Roberts et al., 2008, Feldstein, 1999). However, this would be an inefficient encounter. This is why the clear stipulation on prevention through interim care management provides that equal opportunity to get the right care when one does access the services.

Deprived and ageing populations have been identified for their lower than average dental access rates despite their high needs (Borreani et al., 2008, Gallagher et al., 2009). Currie et al.

(2012) argues that review of contemporary experience indicates that those who require services the most are not getting to dental services. Although disparities in access rates could be attributed to multifaceted factors, which are social, financial, geographical and attitudinal as previously highlighted, It is the responsibility of service planners to tackle these disparities especially at the first point of contact (primary care) and to tailor services to these hard to reach groups (Steele, 2009). As the re-organisation of the dental workforce is also undertaken, these groups who have limited access and high needs should be understood for the nature of demand they would impact on the system, and personnel should be staffed based on this understanding. This falls in line with the five-year agenda for the NHS, which suggests that there is no 'one size fits all' approach (National Health Service, 2014).

## **2.6.6 Proposed changes to NHS dentistry**

In the next few sections each of the proposed changes, care pathways and pilot capitation contracts and the resultant prototypes are critically examined; particularly in reference to how these changes promote skill mix.

### **2.6.6.1 The care pathway approach**

Care pathways are already in use in NHS general health services for management of many chronic illnesses (Vanhaecht et al., 2006). Harris and Bridgman (2010) describe the care pathway approach for NHS dental services in England as a model that can improve commissioning, as well as improve provision of appropriate preventive protocols. Despite their popularity in Europe, care pathways are not universally considered as ideal for team based organisation. Pinder et al. (2005) argues that care pathways generate opportunities for a remapping of practices in a manner that oversimplifies the process and creates misleading assumptions. They reach this conclusion following interviews and observations with a variety of healthcare workers in three areas of South Eastern England who had been providing care using a care pathway approach (Pinder et al., 2005). They also raise issues pertinent to the use of skill mix, suggesting that in circumstances where care pathways delegate care to less-skilled workers, this could lead to blurring of professional boundaries which may re-emphasise turf wars (Pinder et al., 2005).

These issues are particularly relevant to NHS dentistry where, several of the tasks involved in the proposed care pathways would fall within the scope of practice of DCPs. The first review of the pilot dental contract care pathways reported that dentists saw opportunities to use skill mix in the delivery of the preventive aspects of the new care pathway (Department of Health, 2012b). Practitioners who did not already use skill mix required assurance that if the care pathway was a definite part of the future contract they would be willing to include skill mix in their practices (Department of Health, 2012b). This may be as a result of the historical reluctance among dentists in the UK to undertaking preventive tasks (Tomlinson and Treasure, 2006). A later review which focussed on the change in patient base rather than the care pathway indicated that pilot practices with a skill mix structure had lower drops in patient base

than those that did not (Department of Health, 2014a). This is a testament to the varied impact of care pathways.

There are some founded observations from Pinder et al. (2005), which may be relatable to the dental care pathway. They suggested the rigidity of the pathway may omit the plasticity of patients' personal circumstance and hinder meeting patients' actual needs. Feedback from the pilots has suggested that there is a need to have options to omit parts of the care pathway depending on circumstance; for example patients who may not want the preventative plans as part of care and this has since been instituted and contractors can use discretion and have clinical autonomy as long as they make a note of the reason for the departure (Department of Health, 2012b). This is in line with the five-year NHS plan where 'one size does not fit all' and tailored approaches to patient care are encouraged (National Health Service, 2014).

#### **2.6.6.2 Care Pathways and teamwork**

There are those who endorse the care pathway approach and even suggest that it can promote teamwork in health care (Allen et al., 2009, Deneckere et al., 2012b, Gittell, 2002, Gittell et al., 2010). Unfortunately the level of evidence in support of this is low. A trial by Deneckere et al. (2012) is currently under way, seeking to improve the evidence around this claim by investigating the impact of care pathways on teamwork in acute care (Deneckere et al., 2012a). Care pathways are proposed to be more effective in low complexity and low uncertainty care processes (McDonald et al., 2007). With this view, its feasibility in the dental setting is questionable, as the course of dental disease is complex, and disease progression is largely associated with patient behaviour, which raises uncertainty.

Still, the care pathway appears to be a definite part of the new dental contract and managing the inclusion of DCPs in the delivery requires further study. Deneckere et al (2012) particularly suggests that prior to instituting care pathways, it is important to understand all the aspects of the organisational structure, as different components contribute in a varied way to the success of integrating care pathways into the organisation of teamwork plans. It is proposed here in this research that the actual needs, as expressed by the patients, will influence the involvement of the whole dental team in the provision of actual patient-centred care effectively within a care pathway.

### **2.6.6.3 The new dental contract pilots and skill mix use**

Prior to the recent prototype contract developments, there have been three pilot arrangements, which all share the common features of being capitation based. These contracts have shared a quality control element, of conferring a responsibility for long term care of the patient on the contract holder and of being based on an oral health assessment and care pathway (Department of Health, 2012c). In terms of workforce arrangements none of the pilots have created varied models for skill mix/ dental team work to evaluate, however, participating practices are encouraged to develop a system of skill mix for themselves within the new contract provide feedback (Department of Health, 2012c).

In the most recent report from the dental pilots, the use of skill mix emerged as a distinct theme in the analysis of differential fall in patient base across pilot practices (Department of Health, 2014a). A qualitative cross case analysis of different pilot practices, found that those practices with the least fall in access utilised their skill mix and in contrast, those practices whose access was negatively impacted had fractured utilisation of skill mix (Department of Health, 2014a). A number of other factors were listed in association with the fall in access such as no structured management typology, a lack of buy in and little activity toward streamlining their processes to harmonise the practice with contract requirements (Department of Health, 2014a). It appears that for practitioners without an internally built system of management, there was a lower chance of skill mix use, and poor access rates. This relates to the idea that organisational changes require a means to an end analysis (Roberts et al., 2004). There is an indication, from the qualitative findings from the review of the pilots that skill mix use could improve access in the wake of the new contract; however, general practitioners need an organisational understanding of how to achieve this.

### **2.6.6.4 Payment reform in the new contract**

Dental contract payment change is one of the aspects that will be altered in the new dental contract. Payment systems have a resounding impact on the ways in which providers perform services (Roberts et al., 2008). In pilots, a capitation system of payment is proposed (Department of Health, 2010b). There are three models of capitation being tested; however, practice income was not altered. The different pilot models test diversity of environments in

which the care pathway can operate, giving wide comparisons for the final pilot. Pilot type 1 is based on time spent to provide care, Type 2 is based on the number of weighted capitated patients, varying by age, sex and deprivation and Type 3 also based on weighted capitated patients but relates to preventive and routine treatment with a fixed rate of 'band 3 treatments' (Department of Health, 2014a).

Unfortunately income could not be feasibly altered in the pilots, the financial impact of different skill mix could not be tested in the new model (Department of Health, 2012c). Changing skill mix may also have been seen as financially risky by the pilots, and without the certainty of longer term contractual arrangements (Department of Health, 2014a). It leaves a gap in understanding of how skill mix and other factors will work within the future payment structure. Studies have shown that capitation payments in primary care general practices alter provider behaviour, relating to task sharing (Krasnik et al., 1990, Iversen and Luras, 2000, Allard et al., 2011). For example, capitation systems have been associated with increased referral rates to specialists or secondary services more than any other system of payment (Krasnik et al., 1990, Iversen and Luras, 2000, Allard et al., 2011). However, it is suggested that the stringent quality protocols may encourage teamwork (Nuffield Trust, 2012). Both these responses could occur for the same reason; because providers try to save on time. The pilot reports do state that there could potentially be a mechanism enabling practices to compete for patients and the resources they bring (Department of Health, 2014a). This can be justified, if they can ensure that the patients who are most in need are the financially lucrative cases.

An ideal outcome of the capitation arrangements of the new dental contract in England would be to improve the care patients received. From what is known of capitation systems, they rarely have the potential to mitigate risk selection (over-referral of complex patients); which occurs when patients who may seem complex are not selected by health care providers in order to minimise input and maximise on resource. Since capitation payment systems transfer most of the financial risk to providers (Roberts et al., 2004), a risk saving behaviour is likely. As has been seen in previous contract reforms in NHS dentistry, providers find a way to minimise their risks adopting 'opportunism' (Harris et al., 2014). For NHS dental service, this does bring a concern as this may lead to lower chances of incorporating DCPs into practice as practice leads

have already previously been suggested to be unsure of how to measure DCP productivity (Harris and Sun, 2012b).

#### **2.6.6.5 Dental contract prototypes**

Towards the final stages of preparation of this thesis a plan for prototypes of the new contract were set to commence. The prototypes (a blend of two) contain plans for capitation, activity, quality and reward for prevention (NHS England, 2014a). Interestingly the prototypes have steered clear of a full capitation system, highlighting the challenge in approximating the financial risk under such a system. Also, there is the lack of weighting based on age although quality measures to ensure age related guidance on prevention is rewarded. It is alluded to that the final contract will include age and deprivation weighting. It is however stated that this is a step to develop a robust model fit for potential roll-out nationally (NHS England, 2014a).

#### **2.6.7 Summary**

The drivers to change primary dental care are based on actual changes in the requirements of patients who present for care. There are issues of quality, efficiency and access in the drive to change NHS primary care. The skills required will vary as surveys show that younger people are in need of more routine tasks, which could be easily undertaken by DCPs. Older adults have retained teeth longer, some of which may be heavily restored and in need of more complex care. This equates to a need for dentists to spend more time working on complex care, as only they possess those skills, and delegating routine tasks to DCPs. The drivers to change point to a model where health is maintained. This idea is clearly factored into the plans for the new contract with the care pathway. However, the idea that skill mix will be a part of the new primary care function seems more tacit and how it will happen could benefit from more research as no direct skill mix interventions within the pilots have been undertaken. It would seem that the desirable solution would be to maximise on the skills of all members of the dental team and to research to achieve feasible models of skill mix.



## **2.7 The health workforce**

### **2.7.1 Introduction**

So far, the literature review has explored changes in health and strategies to provide health care and maintain health both globally and locally. In this section the roles of the health workforce and the dental team members are addressed specifically. A focussed critique of the development of the role of DCPs in meeting needs is also provided within this section.

It is increasingly recognised that 'Health workers are the core of health systems: without health workers there is no health care' (World Health Organization and Global Workforce Alliance, 2014). Commonly the health workforce shortages especially evident in emerging economies has been considered the main issue related to health workforce planning (Buchan and Campbell, 2013). There are however more issues worth considering, for example in high income countries there has been an over-reliance on migrant workers, which has led to global code of practice limiting the migration of health workers (World Health Organization, 2010). According to Buchan (2013), for high income countries, in order to make improvements in health workforce performance there requires to be better use of current skills, improved skill mix, new roles, effective incentives, supportive working conditions, integration, and teamwork. There is an ongoing consultation to establish a global human resource for health strategy, which will highlight in eight thematic papers the issues surrounding the health workforce to be tabled at the World Health Assembly in 2016 (World Health Organization and Global Workforce Alliance, 2014). Presently, it appears that the global health community is focussed on ensuring that the changes in need and demand are adequately met by a prepared health workforce.

### **2.7.2 The dental workforce**

#### **2.7.2.1 Nature of the dental workforce**

The dental workforce comprises registered dentists, dental hygienists (DH), dental therapists (DT) (referred to as hygiene-therapists at UPDA), orthodontic therapists, dental technicians, clinical dental technicians (CDT) and dental nurses (Gallagher, 2008). The latter six are considered mid-level dental providers, auxiliaries or dental care professionals. In most countries there is an overall council responsible for the registration of medical and dental professionals. This regulatory authority is charged with the responsibility of regulating the professions by

setting standards, training strategies, and registering professionals. Within the UK, the GDC has published learning outcomes to prepare all members of the dental team for practice. The outcomes aim to:

- have a greater patient focus and put their interests and needs first;
- meet current and future oral health needs;
- cover the full range of skills, knowledge and behaviours needed to work in dental practice (i.e. clinical, professionalism, communication, and management and leadership);
- cover all registrant categories in one publication with a consistent approach;
- allow more flexibility for training providers.

Source: General Dental Council (2012)

### **2.7.2.2 Workforce mobility and shortages**

In many African countries there are shortages in dental workers (Kaimenyi, 2004). In some, mid-level dental providers undertake the majority of work in rural areas (Achembong et al., 2012). In the EU a lobbying organisation 'The European Platform for Oral Health' is advocating for oral health teams and automatic registration for providers between countries to aid in worker shortages (Better Oral Health European Platform, 2013).

Workforce migration is a challenge globally (World Health Organization, 2010). And in Europe (Buchan et al., 2014) health professional mobility changes the numbers of health professionals in countries and the skill mix of the workforce, with consequences for health-system performance (Buchan et al, 2014). Some find that currently the majority of workers are moving to low needs areas rather than vice versa, however the policy was intended to improve capacity (World Health Organization, 2010)

### **2.7.2.3 Scope of practice of the dental workforce team members**

In the UK the General Dental Council (GDC) is the responsible authority and it produces the 'Scope of Practice' (General Dental Council, 2013b), which is a document that outlines the skills of each registrant group. The first edition, four years earlier, 'Scope of Practice' (General Dental Council, 2009b), which was in place during the research study period, had stated that patients will not be seen by other members of the dental team before a dentist performs a full

assessment, with the exception of complete denture patients who could be seen for complete denture work only by CDTs. The new regulations broadened the scope of DCPs and widened the possibilities for skill mix use and now dental hygienists and therapists can see patients directly without prescription from a dentist. **Table 2-3** lists dental team members and their roles and summary of their duties. Thereafter, **Table 2-4:** provides an overview of registrants in England and the UK.

**Table 2-3 The dental team**

<b>Professional</b>	<b>Role description</b>
<b>Dental nurses</b>	Registered dental professionals who provide clinical and other support to other registrants and patients
<b>Orthodontic therapists</b>	Registered dental professionals who carry out certain parts of orthodontic treatment under prescription from a dentist
<b>Dental hygienists</b>	Registered dental professionals who help patients maintain their oral health by preventing and treating periodontal disease and promoting good oral health practice. They carry out treatment direct to patients or under prescription from a dentist
<b>Dental therapists</b>	Registered dental professionals who carry out certain items of dental treatment direct to patients or under prescription from a dentist.
<b>Dental technicians</b>	Registered dental professionals who make dental devices to a prescription from a dentist or clinical dental technician. They also repair dentures direct to members of the public.
<b>Dentists</b>	Registered dental professionals who can carry out any dental treatment carried out by the DCPs and all non-specialized dental treatments.
<b>Clinical dental technicians (CDTs)</b>	Registered dental professionals who provide complete dentures direct to patients and other dental devices on prescription from a dentist. They are also qualified dental technicians. Patients with natural teeth or implants must see a dentist before the CDT can begin treatment. CDTs refer patients to a dentist if they need a treatment plan or if the CDT is concerned about the patient's oral health.
<b>Extended duty roles</b>	Registered dental professionals who are DCPs specially trained to conduct duties which were not ordinarily within their scope of practice. For example dental nurses trained to apply fluoride varnish for oral health promotion purposes.

Source: Scope of Practice, General Dental Council, 2013

**Table 2-4 Registrants in England and the UK**

Registration Type	Total		Male		Female	
	England	UK	England	UK	England	UK
<b>Dental Nurse</b>	52,869	42,419	525	651	41,854	52,218
<b>Dentist</b>	30,447	38,915	16,497	20,932	13,949	17,982
<b>Dental Hygienist</b>	5,462	6,580	205	242	5,257	6,338
<b>Dental Technician</b>	5,239	6,313	4,072	4,900	1,167	6,313
<b>Dental Therapist</b>	2,128	2,488	108	130	2,020	2,358
<b>Orthodontic Therapist</b>	2,327	407	7	8	320	399
<b>Clinical Dental Technician</b>	266	305	252	286	14	19

Source: General Dental Council (January, 2015)

The number of dental professionals practising at any given time is a factor of flow between those joining the profession and those leaving. It should be noted that the registration of dental professionals is according to their residence and not necessarily a reflection of where they work. There is a steady supply into the profession through training institutions in the UK and foreign graduates. The most recent Review of Medical and Dental School Intakes in England in 2012 revealed that over 1,100 students are taken into UK dental schools each year (Niven et al, 2013), with numbers in England being reduced by 10% in 2014. The next section describes development of the dental team which has been a goal for dental care provision for some time (Nuffield, 1993; NHS 2002) Options for Change. This has involved attempts to develop the roles of DCPs, while empowering them to contribute more effectively within their work settings.

### **2.7.3 The developing role of dental care professionals**

#### **2.7.3.1 Introduction**

It has been suggested that the speed in which the roles of DCPs have evolved in most countries has been associated with a need to improve access to dental services (Richards, 2013, Nash et al., 2014). In a more philosophical and general sense the development of professional groups has been described as the ability to have jurisdictional claim (Abbott, 1988). Abbot (1988) describes this as a group asking society to recognize its cognitive structure. As mentioned in section 2.7.2 there is a movement within the EU region to move into an oral health team approach, where dentists, as team leaders, can delegate tasks to suitably trained and independently assessed dental care professionals, such as dental hygienists and nurses, with appropriate skills to care for the oral health of the population and provide preventative advice to patients (Better Oral Health European Platform, 2013). This requires a concerted effort between policy, regulatory authorities and educators to ensure the roles and responsibilities undertaken by DCPs is within their scope of training and practice. With this understanding it is clear why the regulations on scope of practice and employment of these professionals has dictated how team work and skill mix have developed globally. This next section examines the processes of role development for these mid-level dental professionals.

#### **2.7.3.2 Overview of role development section**

To outline these processes first, a brief overview of the history of the developing role of DCPs is provided. The review in this section first outlines the common themes associated with role development for dental care professionals in countries around the world. Second, the role development of DCPs in the UK is discussed, with the key historical milestones outlined. More focus is placed on the development of the dental therapists as these are the professionals at the centre of this research.

#### **2.7.4 Dental care professionals worldwide**

Dental care professionals or DCPs are referred to as dental auxiliaries and, in some cases, mid-level dental providers (World Health Organization and Global Health Workforce Alliance, 2010), where patients have direct access to their services without having to be seen first by a dentist.

The scope of practice of DCPs has ranged from assisting the dentist to providing examination, diagnosis and treatment planning; exposing and interpreting radiographs; oral health education; preventive services such as prophylaxis, fluoride therapy, fissure sealants and dietary counselling; preparation of cavities in primary and permanent teeth and restoration with amalgam and composite; preformed stainless steel crowns; pulpotomies; and the extraction of primary teeth (Friedman, 2011, Nash et al., 2014).

When DCP role development is discussed, conversations have revolved around topics such as the range of clinical tasks that they can perform, where they can practice, supervision, accessibility, and most emphatically their cost-effectiveness (Nuffield Foundation, 1993, Harris and Haycox, 2001, Nash et al., 2008, Friedman, 2011). For that reason the role of the dental therapists have been the most debated, due to the wide overlap in skill with dentists and their potential to provide more services at lower costs. Dental hygienist duties lie within the dental therapist's role and in recent years dual training has emerged giving room for the hygiene-therapists (Ross et al., 2007a, Moffat and Coates, 2011). Currently, 54 countries worldwide utilise dental therapists or their equivalent (Nash et al., 2008, Friedman, 2011, Nash et al., 2014). In Brazil, the equivalent mid-level dental provider to dental therapists/hygienists is an oral health technician (OHT) (Sanglard-Oliveira et al., 2012). In New Zealand, Malaysia and USA there are dental therapists (Nash et al., 2008), while the Dutch have oral health therapists (Nash et al., 2008). In the UK, they are dental hygiene-therapists or dental therapists (Gallagher, 2008), in Kenya community oral health officers (COHO) (Kaimenyi, 2004).

#### **2.7.5 Educational development**

New Zealand's school of dental nurses (later dental therapists) established in 1921 (Coates et al., 2009), was the first in the world to train mid-level providers that could undertake preventive and simple restorative tasks on children. Countries such as Malaysia, Sri Lanka and Singapore also started training and employing 'school dental nurses' (i.e. dental therapists) between 1948 and 1950 (Nash et al., 2014). The New Zealand dental therapists have been responsible for the care of children through school dental services (SDS) for almost 100 years now. They are now trained on a three-year degree programme of Oral Health which merges the training of hygiene and therapy roles (Moffat and Coates, 2011). The UK and the US and many other countries have used the New Zealand model to develop training for dental therapists.

The role of dental hygienists has been in place in the USA since 1910, when the first formal school of training in Ohio was started and their training has evolved from an apprenticeship in the 1900s, into a four year programme at present (Milling, 2013). In Europe, the UK began training hygienists in 1928 although this was later stopped and restarted in the air force and later in civilian universities in the 1940s. In Sweden their one year programme began in 1968 (Öhrn et al., 2005). In Sweden the hygienists training includes some therapy roles (Virtanen et al., 2011). All the Nordic countries have a well-developed hygienist role within their dental team (Better Oral Health European Platform, 2013). In the UK and Holland dental hygiene and therapy training has been merged (Nash et al., 2008). In Southern European and countries with Bismarkian health care such as Germany, there are no hygienists or equivalent midlevel dental providers trained (Better Oral Health European Platform, 2013).

In Africa, mid-level provider equivalents to therapists or hygienists are trained to work in the community clinics in some countries (Achembong et al., 2012, Kaimenyi, 2004). In Brazil, the oral health technicians were first introduced in the 1950s with basic rudimentary roles, their training progressed to more operative tasks in the 1970s due to high demand for services (Sanglard-Oliveira et al., 2012). In Kenya, community oral health officers train for three years and are expected to work in community roles with the presence of a dentist (Kaimenyi, 2004).

#### **2.7.6 Licensing, registration and practice setting**

Licensing and regulations on practice settings have played a key role in the development of DCP roles. In most countries DCP roles were initially regulated to allow provision of care to children (Nash et al., 2008). In the USA those commentators opposed to DCP role development have insisted that they can only work in rural areas or where dentists do not want to work and this is perhaps because they see them as a threat to their practice bases and income (Naughton, 2014).

Hygienists have had the ability to practice in general practice before dental therapists in many countries including the USA and UK (Nuffield Foundation, 1993, Johnson, 2003). Hygienists enjoy more acceptability due to their less complex scope of practice. It has, however, been found that in many countries, some of the tasks considered as therapy are performed by hygienists (Johnson, 2003). Some countries allow dual registration for hygiene and therapy e.g.

the UK, so that they could practise their therapy skills in one setting and not another, if they needed to. In Sweden 65% of dental hygienists work in public dentistry and 35% in private dental offices as employees, or independent practitioners (Öhrn et al., 2005). In England, in a recent survey modelling the dental workforce supply in England, dental therapists were reported to work 70% in general dental practice, while hygienists spent 83% of their time in general practice. Unfortunately, therapists only work 41% of their time in therapy roles (Robinson et al., 2011).

The registration of DCPs with official regulatory bodies in various countries, has taken different lengths of time. This may have played a part in how quickly their roles developed. In Brazil, despite the introduction of the Oral Health Therapist [OHT] in the 1950s, it was only in 2008 that they were officially recognised as a professional group (Sanglard-Oliveira et al., 2012). In Kenya, COHOs are not regulated by any professional regulatory body, creating problems in the boundaries of within which they can work (Kaimenyi, 2004).

There is a role for academia to contribute to the development of DCPs roles through research that inform regulation changes and scope of practice. Abbott (1988) outlined the importance of academic support in establishing jurisdictional boundaries as a profession develops. He particularly states that through legitimization, research and instruction, a profession somewhat protects its jurisdiction (Abbott, 1988).

#### **2.7.7 Jurisdiction and professionalization**

A common challenge for professionalization is attaining jurisdictional claim, defined as 'the link between the profession and their designated work range', and involves negotiating in workplace settings (Abbott, 1988). Friedson (2001), argues a similar position but relates jurisdiction to the 'division of labour', proposing that this is central to ideal typical professionalism. According to Abbott (1988) a professional group needs to gain jurisdictional mastery in the area of the public, legal system and work setting. The first two he describes as formal and usually the first to obtain. In the case of DCPs, the legal system would relate to regulations on scope of practice from the GDC in the UK and the public arena would generally be related to the acceptability to the public. The final is work setting, which according to authors (Abbott, 1988, Friedson, 2001), relates to establishing work jurisdictional boundaries.



Settling jurisdictional boundaries can be done through negotiations. In the case of DCPs it has been shown that there is a poor understanding of the scope of practice for the new dually trained professionals or DCPs with extended roles by dentists and this may hinder the progress of team working or negotiation (Ross et al., 2007a, Moffat and Coates, 2011). Some have suggested training dentists together with DCPs, in order to clarify roles (Ross et al., 2009). This would begin to identify the jurisdiction. Moffat et al. (2009) in New Zealand have gone a step further and developed a guideline for dental professionals, which educates them on the dual qualified hygiene and therapy roles (Moffat et al., 2009). According to Abbott (1988) there are five ways of settling jurisdictional boundary issues namely

- i) full subordination
- ii) intellectual subordination
- iii) division
- iv) advisory roles and
- v) client distribution.

The last recommendation by Abbott (1988) 'client distribution' is particularly relevant to dentistry study, where how clinical tasks can be shared is crucial to the development of the roles of DCPs and is the chance to meet patients' needs more efficiently. Abbott's (1988) first four methods of settling jurisdictional boundary problems, possesses a common thread, which is to address the lack of autonomy for the group. This has been a common challenge for DCPs in most countries. In South America, oral health technicians operate with minimal autonomy, and only in public dental services under the supervision of the dentist (Sanglard-Oliveira et al., 2012). Sanglard-Oliveira et al. (2012) argued that their lack of autonomy does bring into question their very identity as a profession (Sanglard-Oliveira et al., 2012). A similar situation exists with dental therapists in the USA. Since 2005, when dental therapists were introduced to serve in Alaska and Minnesota, their practice has largely been met with resistance from dental associations (Friedman, 2011). This opposition is experienced in spite of reports of success in increasing the number of patients seen in practice and in improved job satisfaction of team members due to their inclusion (Post and Stoltenberg, 2014). Turner et al. (2011) argues that the ability to work professionally is contradicted by a lack of autonomy, and most hygiene and therapy associations should continue to strive for more autonomy.

If client distribution is considered in a situation where demand for care is limited, it would be likely that there would be a lack of distribution of tasks. Abbott (1988) clarifies that client distribution could be related to tasks, not necessarily to a group of people. For the dental team either approach could work, as success has been shown in New Zealand, where children have been fully cared for by dental therapists for almost 100 years with great success (Nash et al., 2014). In the Netherlands, where direct access of therapists has been instituted for seven years, studies have shown that there are some examples of good practice working relationships between therapists and dentists; however, the relationships between the professional bodies remain difficult (Northcott et al., 2013). For newly developing professional groups, this highlights the importance of considering establishing rapport with related professional associations and perhaps creating common professional associations as professionals start to cross each other's work boundaries. It was evident that in 1984 when the first DCP member of the GDC was announced (Nuffield Foundation, 1993) a fairer representation of the views of these auxiliaries of the dental team was possible. Perhaps the potential for teamwork without creating jurisdictional battles is for researchers to provide evidence of the most beneficial ways in which DCPs can contribute to meeting demands, allowing all groups to understand the value of the new team driven strategies within the context of the work they need to provide for the population. This can be done through techniques such as modelling and forecasting various scenarios of practice (Health workforce Australia, 2012).

In this section a summary of the process of development for DCPs has been outlined. This section has demonstrated the links between general professional development principles and the current trajectory of professional development experienced by DCPs. In the following section the developing roles of specific DCP groups are examined within the UK, with highlights on specific crucial historical developments.

#### **2.7.8 Dental therapists' in the UK a historical view**

In the UK, dental therapists began working in 1957, when the Dentists Act created the Dental Auxiliary (Therapist) as an experiment (Nuffield Foundation, 1980). Their scope of practice in the UK included similar restorative and preventative tasks to other countries, initially focusing on children and from 1970s permitting caring for adults (Nuffield Foundation, 1993). Like other DCPs such as hygienists, the dental therapists have their roles founded on 'the dental dressers'

of the post-war era in 1917, who were introduced due to overwhelming poor oral health and lack of dentists (Nuffield Foundation, 1993). In 1948, the extent of dental disease was high and the school dental services were neglected by dentists who sought better remuneration in general practice, and so the Government reacted by seeking to introduce a class of worker similar to the dental nurses of New Zealand (Nuffield Foundation, 1993). Only in 1957 was the Government able to introduce dental auxiliaries through the amendment of the Dentists Act. Dental therapists worked strictly under the dentist, and could not even discharge patients without the dentist's permission. This was the result of the wide opposition of dentists who did not believe dental therapists were capable of providing care independently (Nuffield Foundation, 1993).

The New Cross Hospital in South East London in 1959 was a pioneer in training Dental Auxiliaries (dental therapists) and after opening trained 60 'Dental Auxiliaries' a year (Holt and Murray, 1980). After over 20 years of training dental therapists, the New Cross Hospital closed in 1983. After some debate the Royal London Hospital began training in dental hygiene and dental therapy training in 1983. In 1996 Cardiff University started to offer dual hygiene-therapy training. Soon after Sheffield University followed and so did the rest of England (Rowbotham et al., 2009). Scotland began dual hygiene therapy training in 2003 (Turner et al., 2011).

On qualification, dental therapists could only work in the community dental services until 1998 when they were allowed to work in PDS contract schemes as they were considered extension of community dental services (Harris and Haycox, 2001). This was one of the reasons that propelled dual training of hygiene and therapy, in order to allow graduates to have an opportunity to work in general practice as hygienists or in other European countries (Rowbotham et al., 2009). In the year 2000, dental therapists were denied the right to work in all areas of dentistry by the privy council, in a move that retained the 1984 Dentists Act, limiting the work of therapists to the NHS; hence, they were not permitted to work in the private sector (Grace, 2000). At around this time a survey showed that the majority of therapists were taking career breaks, working part-time and some took up illegal roles (Gibbons et al., 2000). Finally, in 2002 dental therapists were allowed to work in general dental practice as therapists. It was, however, found that even a few years later the majority of dually qualified hygiene-therapists continued to work in hygiene roles rather than therapy (Godson et al., 2009). Further still, the

majority of dental practitioners in England, Scotland and Wales had limited knowledge of their scope of practice (Gallagher and Wright, 2002, Ross et al., 2007a, Jones et al., 2007a).

Currently 20 schools in the UK are offering courses for a dual qualification of dental hygiene and therapy (British Association of Dental Therapists, 2014). The course is a two-year diploma programme in most universities, there is, however, a Bsc in Oral Health Sciences offered for three years. There is also voluntary vocational training for dental therapists first established in 2008 (Bullock et al., 2013). Bullock et al. (2013) studied three cohorts of VT training for dental therapists and found that it was an opportunity to develop confidence and skills in a supportive environment, but cited difficulty in having these trainees maintain the full range of their skill in practice. There is a suggestion that there is room to consider education of GDPs on the work that therapists are qualified to carry out and on how they can contribute to the dental team (Eaton, 2013). This was largely suggested when therapists' roles were expanded to all of general dentistry (Jones et al., 2007a, Ross et al., 2007a). It is clear that the majority of routine dentistry can be undertaken by dental therapists based on the 'Scope of Practice' (2013).

The most recent and dramatic development in the role of DCPs is the Direct Access regulation of 2013 (General Dental Council, 2013a). Although this permits patients to be seen by dental therapists and hygienists without a prior visit to a dentist, it does have its practical limitations. First dental therapists still require prescriptions for local anaesthetics and for many of the emergency medications required to be in any working dental surgery, albeit that this can now occur under a 'group directive' (Dental Protection, 2014). Second, the fact that at present only a dentist can open or close a treatment plan on the NHS, limits the possibility of dental therapists or hygienists working as sole traders in the NHS practices (Wake, 2014). Wake (2014) describes direct access as an opportunity for team work and DCPs involved will be required to refer whenever a task is outside their scope. It is noted that dental hygiene and therapy graduates post 2002 will have all the skills necessary to take on the new role of assessments (General Dental Council, 2013b); however, those qualified prior to 2002, may need to consider courses to expand their skills (Dental Protection, 2014).

At present newly qualified dentists are the most concerned about the growing scope of dental therapists (Holden, 2012). The young dentists highlight that the training of hygiene-therapists is

considerably shorter and the responsibility towards diagnosing conditions such as oral cancer could not be delegated to hygiene-therapists. Holden (2012) goes on to propose that 'to blur the distinction between different dental professions would be an irresponsible'. This type of rhetoric highlights the push and pull between professional groups; with some trying to reaffirm their jurisdiction (dentists) and others attempting to widen theirs (DCPs). As Rowbotham et al. (2009) proposed, hygiene-therapists are capable of substantially contributing to expansion of NHS services provision and preventative care and a unified approach would be necessary. It is however, a difficult premise to undertake, with huge opposition including from professional bodies such as the British Dental Association. The current climate is one that is being carefully negotiated, with research that improves the knowledge in regard to the abilities of dental therapists (Macey et al., 2015) being continuously requested. Below is a summary of significant milestones in development of the dental therapist role in England.

**Table 2-5 History of dental therapists in England**

<b>Year</b>	<b>History</b>
<b>1917</b>	Dental Dressers' were established in England and filled cavities in the First World War
<b>1921</b>	The 1921 Dentists Act allows any person to perform minor dental work under the supervision of a registered dentist
<b>1956</b>	Training of dental auxiliaries in England allowed in the dentists act due to shortage of dentists
<b>1959</b>	The first school for training Dental Auxiliaries was opened at New Cross Hospital in south east London trained to carry out restorations in primary and secondary dentition – Black Cavity Classifications Class I-V – to extract deciduous teeth – give infiltration anaesthesia – take and develop x-rays, scaling and dental health education. In fact this remit did not change until 2002.
<b>1983</b>	New Cross was closed and the London dental school opened a school, since then 27 schools UK wide train therapists
<b>1984</b>	Dentists Act states that therapists can only work to provide conservative treatment in NHS
<b>1998</b>	Dental therapists allowed to work in PDS schemes because they are considered an extension of CDS
<b>2000</b>	Privy council denies a request for dental therapists to work in all areas of dentistry
<b>2002</b>	Dentists Act was reviewed and amended and Dental Therapists were allowed to work in general practice and along with that the remit to 'extended duties'. These included administration of ID Blocks (dentist must be on premise), pulpotomies on deciduous teeth and impression taking, without necessarily having the dentists on the premises.
<b>2008</b>	All DCPs registered with GDC and compulsory Continuous Professional Development (CPD) with the requirement of 150 hours over a period of five years.
<b>2008</b>	Voluntary vocational training of dental therapists available for the first time in the Oxford and Wessex Postgraduate Dental Deanery's dental therapists' foundation training (TFT) scheme
<b>2011</b>	DCP associations asked by the GDC to submit proposals for direct access.
<b>2011/12</b>	Dental therapists calibrated and participate in the 2011/12 National Epidemiological Survey
<b>1st May 2013</b>	Direct access commenced whereby patients may see a dental therapist directly; however, NHS policy remains unchanged despite professional policy having changed

Sources: Nuffield report (1993), Grace (2000), Nash (2008), Patel et al (2012), General Dental Council (2013), Wheeler(2015)

### **2.7.9 Dental hygienists in the UK**

The history and the role of dental hygienists is intertwined with that of dental therapists, with various aspects covered in the section 2.7.3. The role of hygienists was first defined in the 1921 Dentists Act and it has remained the prevention of oral disease and promotion of wellness (Johnson, 2003). In 1928, a formal scheme was developed but later abandoned due to resistance from other dental professionals (Nuffield Foundation, 1993). In 1942, a Civilian Consultant to the Royal Air Force (RAF) in a report to the Director of Dental Services, suggested that dental hygienists should be employed to help alleviate gum problems for air force personnel and in 1943 a 16-week training programme began (Wheeler, 2015).

In 1949, the Eastman Dental Hospital in London started a trial programme training civilian hygienists, and in 1955 the graduates from this institution were the first DCPs to be permitted to practise in General Dental Services under supervision, under the 1957 Dentists Act. In 1961, RAF hygienists could be registered with the GDC following examinations. In 1991, they were allowed to work under a dentist and not necessarily under direct supervision (Nuffield Foundation, 1993). In 1995, the GDC announced that all hygienist programmes would run for two years as opposed to one (Clitter, 1995). In 2002, duties were extended to allow inferior dental nerve blocks, crowns, impressions and treating sedated patients as long as the dentist was present (Wheeler, 2015). In 2009, this was repealed in 'the scope of practice' and dentists did not need to be present and a prescription from a dentist could last three years (General Dental Council, 2009b). Apart from dental therapists and clinical dental technicians, hygienists are the only other DCPs who can now see patients without prescription of a dentist following the direct access regulation (2013). Below is a table highlighting significant milestones in the developing role of hygienists in England.

**Table 2-6 History of the dental hygienists in England**

<b>Year</b>	<b>History</b>
<b>1917</b>	Dental dressers employed by local authorities performed minor dental work
<b>1921</b>	Dentists Act allows any person to perform minor dental work under the supervision of a registered dentist and the hygienists are limited to work in hospitals and public services
<b>1928</b>	University College London started a scheme to train dental hygienists which was opposed and stopped
<b>1932</b>	The definition of minor dental work is limited to scaling and polishing
<b>1942/43</b>	Mr Kelsey-Fry suggests hygienists are employed in the Royal Air Force (RAF) to aid in rife gum problems and RAF training of hygienists begins
<b>1949-1954</b>	Eastman begins training civilian hygienists
<b>1955</b>	Dental hygienists became the first operating auxiliaries to be permitted to work in General Dental Services
<b>1957</b>	The 1957 Dentists Act stipulated that a dentist had to be present when hygienists worked in general dental services
<b>1961</b>	RAF hygienists first allowed to undertake final exams so as to be registered with GDC
<b>1974</b>	Hygienists were permitted to use fluoride gels and fissure sealants
<b>1984</b>	One member of GDC would be a dental auxiliary
<b>1991</b>	Hygienists can work simply under direction of a dentist not under supervision
<b>1995</b>	GDC announced all programmes would run for 2 years and not one
<b>2002</b>	Dentist did not need to be on the premises for local anaesthesia administration except for inferior dental blocks. Duties were extended
<b>2008</b>	All DCPs registered with GDC and CPD with the requirement of 150 hours over a period of five years.
<b>1st May 2013</b>	Direct access was enforced and patients can see a dental hygienist before visiting a dentist

Sources: Nuffield report (1993), Nash (2008), General Dental Council (2013), Wheeler (2015)

#### **2.7.10 Other DCPs in the UK**

Other DCPs such as clinical dental technicians (CDTs), orthodontic therapists and dental nurses have also had their roles develop through the years. CDTs first started as dental mechanics in 1941 and trained through apprenticeships in dental laboratories (Ross and Ibbetson, 2005). In 1945 the Teviot report advised the development of more theory in the



training of dental mechanics (Taylor, 1945). In 1951 dental mechanic courses were replaced with dental technology. Currently Dental Technicians are registered dental professionals who make dental devices to a prescription from a dentist or clinical dental technician and they also repair dentures direct to members of the public (General Dental Council, 2013b).

Dental nurses' roles evolved from that of the dental assistant (Nuffield 1993). Most historical reports discuss this group of DCPs as dental assistants. They have had a mixed form of training which has been formal (courses, often evening classes) or informal (apprenticeships). They are now fully registered with the GDCs and most of their courses run from between one year and 15 months. Since 2009, the scope of practice of dental nurses has been extended to support public health directives that require preventative care provision to target groups, and they are referred to as Extended Duty Dental Nurses (EDDN) (General Dental Council, 2009b). They were permitted to apply fluoride varnish. There is wide acceptability for EDDNs, and several schools based interventions are co-ordinated through the use of EDDNs. Guidance at first stressed that the application of fluoride varnish by a dental nurse must be part of a programme, which is overseen by a Consultant in Dental Public Health or a registered specialist in dental public health (Department of Health, 2009). This was later repealed and a dentist did not necessarily have to oversee. This guidance has provided an opportunity for dental nurses to have much more direct involvement in preventive procedures and has allowed for wider reach of programmes such as Childsmile (fluoride varnish application for children in Scotland) (Zhou et al., 2012, Gnich et al., 2014).

#### **2.7.11 Summary**

Section 2.7 of the literature has presented the health workforce, and identified the different members of the dental team, showing their scope and potential in meeting the dynamic demands on the health system. It has provided an overview of the potential for developing dental teamwork by exploring the factors influencing the development of DCP roles. This has explored the philosophical aspects of professional development and how this has related to DCPs. The literature has also shown, through historical review, that there are common limitations experienced in developing the dental team members' roles. Policy and regulation adjustments have been identified as central in improving the opportunity for sharing of tasks between dentists and DCPs, particularly hygiene-therapists. As this research purposefully

focuses on the potential to share duties between dental hygiene-therapists and dentists by identifying how DCPs contribute in primary care, this section of the literature acknowledges the wider issues associated with successful teamwork in the dental team.

## **2.8 Skill mix**

### **2.8.1 Introduction**

This section examines the definitions and processes of skill mix in health care. It identifies role of skill mix within general and global health, while showing the challenges of skill mix implementation as evidenced by research and commentators.

### **2.8.2 Skill mix defined**

The term skill mix has been broadly referred to as 'the combination of activities or skills needed for each job within an organisation' (Buchan and Dal Poz, 2002). The WHO's definition of 'Skill mix' suggests that 'it is the mix of posts or occupations in the health system, the demarcation of roles and activities among different categories of staff, the combination of skills available at a specific time, or the combination of skills needed for each role within the system' (World Health Organization et al., 2009). According to Sibbald et al.(2004), management of a skill mix amidst a group of professionals can be carried out by 'enhancement of duties, substitution of workers, delegation of duties within the uni-professional chain and innovation of new jobs'. Other researchers have suggested that part of the process of implementing skill mix is robust evaluation of existing skill mix, which may inform effective extension of duties, role substitutions, delegation and role development (Buchan and Dal Poz, 2002, Sibbald et al., 2004).

Commentators commonly propose that the central drivers for skill mix in the provision of health services, have been skill shortages, cost containment, quality improvement, technological innovations, new health sector programmes and health sector reforms (Richardson et al., 1998, Richardson, 1999, Buchan and Dal Poz, 2002, Kernick and Scott, 2002, Gupta et al., 2003, Fulton et al., 2011). Delegation of tasks to less qualified lower cost practitioners - a type of skill mix optimisation measure - has been the more predominant of the skill mix strategies (Chapko et al., 1985, World Health Organization, 2007b, Lehmann et al., 2009, Selke et al., 2010). It has been suggested that the main driver to task shifting or delegation is the idea that it costs less; however the evidence is low (Dubois and Singh, 2009). Buchan and Dal Poz (2002) argue that

using cheaper staff will not be effective in all situations. It has been proposed that it is more pragmatic for decision makers to consider both the unit costs of labour and data on outcomes and time taken per task, if they are to identify the optimal skill mix (Richardson et al., 1998).

For some, the role developments for lower levels of staff through skill mix have had significant impact on the process of implementation, as they may view skill mix implementation as the blurring of professional boundaries, representing a challenge to perceived established hierarchies (Pinder et al., 2005). This is detailed in Section 2.7.7, where the jurisdictional claim 'constitutently' makes a profession recognised as such (Abbott, 1988). Still, there are wider aspects such as patient outcomes, which have been proposed to improve in sectors that promote skill mix, and since in reality, human resource planning for health should relate not only to cost, but additional parameters such as preferences, availability, quality and, importantly, patient outcomes. (Sibbald et al., 2004, Segal and Leach, 2011).

Dubois and Singh (2009) in their paper discussing a systematic approach to skill mix management, propose the idea of skill mix management which requires health care planners to actively think of role development. This flexibility within service delivery allows efficiency and effectiveness, with full utilization of resources available. This idea is shared in the WHO scale up of the health workforce guidelines, where it is suggested that career progression and role expansion should be considered for all health workers routinely (World Health Organization, 2013a). Therefore, although it is suggested planners should not shy away from developing role development plans for those with a wider responsibility to society, it may be easier for larger organisations such as hospitals rather than dental practices which operate as small businesses.

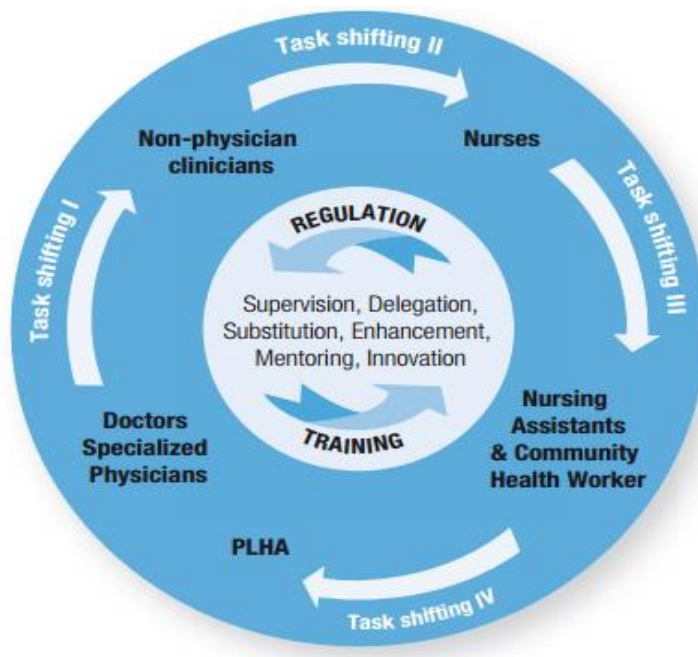
It is suggested that health policy makers, when applying skill mix optimisation strategies, focus on models of skill mix that ensure better health outcomes for patients (Richards, 2013). Primarily, it is important to monitor the number of personnel, their activities, training and professional regulation in order to be successful in ensuring strategies are focussed on the patients' best outcomes (World Health Organization, 2009). An example of this has involved nursing ratios, which have gained extensive popularity in terms of planning for patient outcomes. It is proposed that higher nursing ratios will improve quality and patient satisfaction (Horrocks et al., 2002). Physician numbers have also been associated with quality of health

service, and researchers have proposed that a higher number of specialists or physicians reduces the chances of adverse outcomes or leads to lower mortality rates (Nash et al., 1999).

### **2.8.3 Use of Skill mix: A global view**

Use of skill mix in the global arena is commonly referred to as task shifting and it is described as a process of delegation whereby tasks are moved, where appropriate, to less specialized health workers (World Health Organization, 2007b). A systematic review by Fulton et al (Fulton et al., 2011), predominantly centred on developing countries, found potential for productive efficiency improvements through skill mix and task shifting.

The majority of developments in task shifting have been seen in developing countries. Task shifting has been described as the answer to the crisis in worker shortages in Africa (Lehmann et al., 2009). The scourge of HIV and health worker shortages in the continent, has led to a need for redistribution of responsibility to meet the high demand for care. The use of task shifting has proven extremely useful where new tasks have been introduced due to epidemics. For example, in Ethiopia, nurses were found to be spending 20% of their time on antiretroviral therapy advice following the scourge of HIV, and it was necessary to plan for expanded roles of other workers or cadres of professionals in order to obtain support for these new tasks (World Health Organization, 2007b). And at the present time the epidemic of Ebola has seen ordinary people take on roles administering care using home care kits with their loved ones due to lack of space in hospitals (Lewis and Giahyue, 2014). Figure 2-5 below show how the shifting of tasks can expand further into community contributors in order to meet demand for care.



Source: WHO (2007) Task shifting to tackle health worker shortages  
[http://www.who.int/healthsystems/task\\_shifting\\_booklet.pdf](http://www.who.int/healthsystems/task_shifting_booklet.pdf)

**Figure 2-5 Task shifting: expanding the pool for human resources for health (WHO, 2007b)**

In a general sense the idea for skill mix is to work as a team with flexibility and this may at times involve blurring the traditional professional boundaries; the benefits are however possible if enough political will is available and a robust regulatory framework is in place (Lehmann et al., 2009).

## **2.8.4 Teamwork in primary care: The policy perspective**

### **2.8.4.1 Introduction**

This section chronologically highlights the policy documents in England that have described the need for teamwork in primary care in order to meet the demands of the population. To note, the policy documents have involved an initial general health workforce directive, followed by specialised policy documents related to dentistry. By highlighting these documents some of the dissonance that exists between policy and actual practice becomes evident. As it becomes apparent that even with policies that advocate change, regulatory bodies and systems may lag behind implementing change that could aid improving the scope of professionals or use of skill mix. Furthermore, change may not be supported by other professional groups.

### **2.8.4.2 Teamwork and policy in England**

Since the late 1990s, the Government has suggested a need for flexibility within the primary health care team, where delegation of care occurs between members of the primary care workforce team (Jenkins-Clarke et al., 1998). These proposals have been made through workforce planning policy documents. Commonly, these documents have proposed flexible workforce arrangements as a means for the improvement of the quality and availability of health care. 'A health service of all the talents: Developing the NHS workforce' (Department of Health, 2000a) is a national policy document that emphasised the need to plan the health workforce in a manner that reflects the modern NHS which is patient centred. The documents recommends for all NHS health worker to work flexibly, encouraging the integration of workforce planning across professionals and flexibility of deployment of staff in order to maximize on skills. Exclusive to dentistry, 'Modernizing NHS dentistry' (Department of Health, 2000b), was released in the same year; 2000. This document supported the core principles of the NHS plan, and focussed on tackling inequalities in oral health such as poor access to NHS dental care. The Government mentions 'making the best use of professional skills' and the need for the dental team to work in a complementary manner is emphasised, which is a similar message to the overall health workforce policy document 'A health service of all the talents: Developing the NHS workforce; 2000' (Department of Health, 2000a).

Although these two policy papers promoting teamwork and role development were published in the year 2000, in the same year, the Privy council denied therapists their petition to work in general dental practice. It was only two years later did the role of dental therapists expand to allow them to work in the general dental services (General Dental Council, 2002). Worth noting is that in the year 2000, around the time the policies were published, there were pilots for extension of duties for therapists under way in high needs areas such as East London, and this gave an indication of the potential support for the role expansion of therapists (Goodwin et al., 2003).

Following these documents, in 2001, 'Working Together, Learning Together: A Framework for Lifelong Learning' (2001) (Department of Health, 2001), was released. This paper emphasised the need for workforce planning that targeted those responsible for life-long training for the health worker; this was a move to involve educators of the health workers in developing the desired flexible health workforce. The document encouraged health professionals to have personal development plans, and indicated the need for flexibility in their roles as health workers. The need for more places for enrolment in continued training was mentioned, and the benefits of inter-professional learning environments were championed within this document. This gave way to the development of a 'Primary care workforce planning framework' in May 2002 (Department of Health, 2002b). This framework devolved workforce planning to Primary Care Trusts (PCT). It outlined the need for PCTs to commission the workforce they required, while also recommending the development of local training that involved inter-professional learning (Department of Health, 2002b). This was to encourage the development of skill mix within primary healthcare, in order to provide a patient led service. Concurrently, it was only at this point that the Dentists Act was amended and therapists could work in general practice along with a remit to extended duties (Wheeler, 2015), but inter-professional learning was still not occurring.

In 2004, the primary care dental workforce review report was released to tackle key issues that surrounded the changing workforce need and dental contracts and also the revision of the roles of therapists and hygienists (Department of Health, 2004c). The document revealed the shortfall in supply of dentists and the projections if changes were not made. This document also emphasised the need to optimise the skill mix available within the dental team. The result was

an increase in dental student number intakes and new DCP training institutions. In 2005 'Choosing better oral health: an oral health plan for England' (2005) (Department of Health, 2005a) was released and this reiterated the workforce planning directives by previous policies encouraging skill mix. 'Choosing better oral health an oral health: plan for England' (2005), examined the need for workforce planning based on oral health needs, determined by dental public health professionals. The development of personnel was discussed with direct steer towards collaboration with the GDC and deaneries on training in dental public health and prevention.

In the year 2008, 'A High Quality Workforce: NHS Next Stage Review' (2008) (Department of Health, 2008a) was released and in this document, the roles of the various members of the health workforce are described (Department of Health, 2008a). Emphasis was made for training a workforce able to cope with the changing trends in the populations' oral health. These changes were, and are, attributed to different oral health status of ageing population's. The Government had engaged Medical Education England in the responsibility to plan for education and training of medical and dental professionals; this is now the responsibility of Health Education England (HEE) (Health Education England, 2014b). The Dental Programme Board was an arm of MEE and during its time ran six work stream projects to improve the dental workforce. Concurrently, DCPs were also required to register with the GDC and undergo Continuous Professional Development (CPD) (General Dental Council Revalidation Working Group, 2008).



**Table 2-7 Dental programme board work streams for the former Dental Programme Board**

<b>Work streams</b>	<b>Aim of the work stream</b>
<b>1: Demand for dentistry</b>	To estimate the demand for both NHS and private dental services in order to inform future forecasting of dental workforce requirements.
<b>2: Dental workforce supply-side model</b>	To establish what the workforce capacity is, taking into account the increasing number of dentists and DCPs in training.
<b>3: Skill mix</b>	To assess the contribution that DCPs (such as dental therapists and dental nurses) can make to the delivery of dental care. Also to identify innovations, opportunities and barriers relating to optimized skill mix.
<b>4: Small dental specialties</b>	To establish the number of specialists required in each of the thirteen dental specialties and the number of the training posts required for achieving and maintaining these numbers.
<b>5: Review of oral surgery</b>	To identify examples of good practice around the deployment of oral surgeons in the delivery of NHS dentistry and, taking account of these examples, to assess the scope for their wider use.
<b>6: The introduction of foundation training to dentistry</b>	To explore the introduction of a two-year foundation training course for newly qualified dentists (as resources permit) to replace the one-year vocational training course currently in existence

Source: [Dental Programme Board, \(2009\)](#)

The White Paper 'Equity and Excellence: Liberating the NHS' (Department of Health, 2010a), reiterated the Government's commitment to providing the highest quality of care governed by the patient's need. The current emphasis is on ensuring the supply of skilled workers and a value-for-money health workforce with additional emphasis on multi-professional training and placements in order to achieve these goals (Department of Health, 2010a, Department of Health, 2011a, Department of Health, 2012a).

Within the most recent white paper, almost 10 years after 'Options for Change', the Government has even more firmly encouraged a patient led service and modernised the use of skill mix (Department of Health, 2012a). Policy has also emphasised the need for the flexibility of roles and range in the scope of practice of various members of allied professionals. This has led to various licensing councils to review their scope of practice, allowing professionals to maximise their skills (Department of Health, 2010a). Health Education England was given the mandate to deliver high quality, effective, compassionate care: developing the right people with the right skills and the right values. The five-year forward NHS plan is now structured to be more patient centred and continues the emphasis on teamwork (National Health Service 2014).

## **2.8.5 Dental skill mix implementation in the UK**

### **2.8.5.1 Introduction**

Developing utilisation of skill mix has been suggested as a potential means to improved service capabilities in dentistry as highlighted also in Section 2.5. In the UK, the Nuffield Report (Nuffield Foundation, 1993), gave a vision of skill mix over two decades ago, highlighting the need for the development of the roles of the DCP and the potential for teamwork and task delegation in the dental team. In this section the common debates outlined in the literature around the implementation of skill mix in the UK are explored; this differs from approaches that have identified the drivers of skill mix such as Bullock and Firmstone (2011), who show a pyramid of drivers, if altered, either propel or hinder the implementation of skill mix. The Bullock and Firmstone (2011) pyramid has three layers: at the top dental therapists and the dental practice leaders, who play the main role in staffing; in the middle is the dental practice, which includes all the complex financial aspects of a small business, including size and location, and at the base of the pyramid are national, regulatory and funding arrangements which play a major role in how DCPs can be employed, their scope of practice etc. This highlights the fundamental role that informed policy can have on the progression of skill mix (Bullock and Firmstone, 2011). In this section common arguments in the literature are explored, indicating the push and pull areas of the skill mix debate.

### **2.8.5.2 A case for skill mix in NHS dentistry**

Researchers in the UK have highlighted that optimising skill mix, which involves team based working, is an area where the dental profession lags behind its medical counterparts (Gallagher and Wilson, 2009, Brocklehurst and Tickle, 2011b). Those who advocate the use of greater skill mix (Galloway et al., 2002, Evans et al., 2007), have commonly proposed cost saving and increased productivity as benefits. Research and policy have recommended that dentists maximise the skills of DCPs in their practice teams, through the delegation of duties that are within the DCPs' scope of practice (Department of Health, 2002a, Galloway et al., 2002, Scottish Government, 2010, Ross et al., 2007a). A team model of care where the dentist conducts assessments and prescribes routine procedures to the DCPs, has been proposed for some time (The Royal Commission, 1979, Nuffield Foundation, 1980, Nuffield Foundation, 1993). This was followed by a call for more autonomy for DCPs and direct access of patients (Ward, 2006). And, since April 2013, 'Direct Access' of patients to DCPs without prescription from a dentist has been passed as a professional regulation (General Dental Council, 2013a).

The future of NHS dentistry has potential for a strong use of skill mix, as posited by government policy documents (Department of Health, 2010a, Department of Health, 2011a, Department of Health, 2012a). Successful skill mix enhancing programmes such as the extended duty nursing services of the Childsmile fluoride application programmes in Scotland (NHS Scotland, 2011), are some of the contemporary continuing examples of the benefits of skill mix in delivering prevention. Each of the challenges of implementation in primary dental care is addressed below.

### **2.8.5.3 Challenges implementing dental skill mix in the UK**

#### **2.8.5.3.1 Cost**

The first common theme identified in the literature around skill mix implementation is the uncertainty around the cost-effectiveness of skill mix. This has been cited in most initial articles about dental skill mix, as it was argued that skill mix would be cost-effective based on the lower pay of hygienists and hygiene-therapists (McKendrick, 1971, Scarrott, 1973, Woolgrove and Boyles, 1984). Other commentators have had an opposing view, suggesting that the unit cost of DCPs such as therapists increases as they receive more training (Williams et al., 2009). This is

argued in general health as well (Richardson et al., 1998). Richardson et al. (1999) showed that nurse trained personnel replacement for doctors had led to cost saving; however, as their new roles developed, their pay increased. He argues that greater use of economic evaluation for skill mix, while factoring better or equal outcomes, is a desirable way to plan for the workforce in times of finite resources (Richardson, 1999). In general dental practice research, evidence suggests that greater skill mix through the use of dental therapists, is considered a 'cost' to practices in the current NHS system in England (Harris and Sun, 2012b). Research on general dental practice payment systems in practices using skill mix uncovered shortcoming in the dental contract based on units of activity, which limits flexibility, rendering the potential for cost-effective skill mix practice unclear (Harris and Burnside, 2004, Ward, 2006).

The challenge for some practitioners is how to remunerate hygiene-therapists' contribution as compared to dental associates (Williams et al., 2009). The result has been varied models of practice organisation to include dental therapists (Sun and Harris, 2011). Sun and Harris (2011), described two prevalent practice organisation models, one where the dentist pays the dental therapist, or another where the practice contributions are used to pay the dental therapist. In all the 6 practices research, they found that all the dental therapists were paid either by salary or an hourly rate and the result was more success in the smaller practices than in the larger practices (Sun and Harris, 2011).

#### 2.8.5.3.2 Misconceptions regarding roles

A second reason proposed for the low use of skill mix is the misconception regarding the role of the hygiene-therapist (Douglass and Lipscomb, 1979, Hay and Batchelor, 1993, Ireland, 1997, Gallagher and Wright, 2002, Ward, 2006). This poor understanding of DCP's scope of practice has also been reported internationally in countries including New Zealand (Moffat and Coates, 2011). It is, however, surprising that a study conducted in 1990 in Michigan, USA found that although the dentists in the study had the correct understanding of the auxiliary procedures hygienists could perform, they still did not delegate these tasks to them (Pritzel and Green, 1990). Such findings may relate to the protection of income and further exhibit how the economics and business side of dentistry can affect practices. In countries such as Malaysia hygiene-therapists have a longer history, and this is reflected in a study by Nor et al. (2013) who found that Senior Dental Officers were positive about the contribution of dental therapists in

services provision and had a good understanding of their roles (Nor et al., 2013). Lack of knowledge by dentists is more of a common challenge for dental skill-mix use in the UK and countries like the US where there is a historical reliance on dentists.

#### 2.8.5.3.3 Acceptability of DCPs

A third reason proposed for the poor use of skill mix has been around acceptability. The question maybe whether it is acceptability to the patients or professional colleagues (dentists). It has been argued that acceptability by the public may limit the use of skill mix to a great degree. Both Abbott (1988) and Freidson (2001) both highlight the importance of public acceptability for professional development. In some South American countries this is a major concern (Sanglard-Oliveira et al., 2012), with a mistrust of the capabilities of the mid-level providers having led to stagnation of their role development.

In the UK, research on the acceptability of skill mix by the public has shown skill mix is acceptable, but knowledge on their roles is unclear (Dyer and Robinson P.G, 2008, Dyer and Robinson, 2009, Dyer et al., 2010). There is variation between dental hygienists and dental therapists. More recent work has shown that patients found trust and familiarity with the dental team was most important and clinician experience was more important than clinician qualification for patients (Dyer et al., 2013). Some studies have shown that patients are more satisfied with the service provided by DCPs (Sun et al., 2010); the reasons for this are unclear. In addition, due to the complexities involved in the use of patient reported satisfaction as a measure of quality of care (Williams et al., 1998), these findings cannot be generalised as a true reflection on the actual quality of care provided. This type of analysis has been done by looking at the quality of work performed by dental therapists. Previous studies have investigated the retention rates of fissure sealants performed by dentists and those performed by DCPs and showed that there were no significant differences in the three-year retention rates of the two groups (Nilchian et al., 2011). More recent studies support the use of dental therapists in screening for oral cancer (Macey et al., 2015) and epidemiological surveys (Patel et al., 2012). To this point the constant call is for more research that reveals the contributions of DCPs (NHS Education for Scotland, 2014). It is therefore suggested that further work be undertaken and perhaps the appraisal of protocol or treatment could provide a more comparable measure between dentists and DCPs.

#### 2.8.5.3.4 The unfavourable dental contract arrangements

A fourth reason commonly outlined in the literature, has to do with the NHS dental contract system in England, intertwined with the issue of cost. The current contract, based on UDAs where the link between payment and care is purposely 'broken', has been identified as discouraging towards the use of skill mix (Brocklehurst and Tickle, 2011a, Harris and Sun, 2012b). Sun et al. (2012) highlight a lack of management information that has led to challenges for dentists on how to assess productivity in order to remunerate DCPs accordingly. In addition, the lack of adjustment of the GDS and PDS contracts to allow DCPs to become 'performers' and claim for activity does limit their using these skills in the NHS following the approval of direct access arrangements (NHS Education for Scotland, 2014, Wake, 2014).

### **2.8.6 Dental skill mix implementation in England: points to consider**

#### **2.8.6.1 Introduction**

This section provides a brief overview of critical factors that relate to skill mix optimisation strategies in primary dental care in England. This is done by amalgamating the different concepts addressed in previous sections of the literature. The use of skill mix in NHS dentistry is an organisational shift that has incurred challenges in its implementation. These challenges have been associated with misconceptions regarding the role of team members; particularly hygiene-therapists (Douglass and Lipscomb, 1979, Hay and Batchelor, 1993, Ireland, 1997, Gallagher and Wright, 2002, Ward, 2006). There appears to have been too much oversight and lack of autonomy from regulation (Turner et al., 2011), and the question financial viability in the organisational business model of dentistry has also contributed to a lag in dental skill mix use (Ward, 2006, Williams et al., 2009, Brocklehurst and Tickle, 2011a, Harris and Sun, 2012b). There is professional suspicion/ antagonism (Holden, 2012), especially to certain groups of DCPS such as therapists. And as hygienists are better accepted, and as policy has shifted towards a dual qualification, therapy skills end up under-utilised (Godson et al., 2009).

Profitability is of central value in the business of dentistry and staffing aspects of practice such as introducing DCPs have also been organised around this central value. Roberts et al. (2008) recommended a systematic careful consideration and prediction of the effects of organisational change on the intermediate and overall outcomes. Further, it is proposed by this research that

approaches such as modelling, can demonstrate the potential outcomes of skill mix use in a variety of circumstances, following an understanding of the predictors of the primary dental care needs.

#### **2.8.6.2 Points to consider for the future of skill mix**

The first point to consider is the concept of efficiency. At present, dental skill mix implementation research in the UK is focussing on technical efficiency (Brocklehurst et al., 2013). This indicates that the issue under scrutiny, by definition, is the number of inputs (personnel) and outputs (dental visits or patient episodes) (Linna et al., 2003). This excludes a consideration of appropriate outputs associated with the patient's needs or outputs that may lead to either better patient outcomes or satisfaction. Indeed the subject of need and demand is a tenuous one, and some may suggest that the focus for dental service plans should be on balancing resources, demand and need (Currie et al., 2012). It is argued here that encompassing these facets is related to investigating the prevailing expressed needs or demand for care. This is in line with proposals made by Swedberg et al. (1995), who proposed a more practical approach of efficiency reporting, related to dental care effects, based on rules for input costs for dental clinic activities, valid country-wide criteria for work times of the dental personnel, dental care economics, and current epidemiological indices (Swedberg, 1995). Swedberg (1995) further suggests that considering these elements as inputs and outputs may make it possible to adapt the need of resources in dental care, and to obtain essential information concerning the choice of dental team models (Swedberg, 1995).

The second point is whether research on dental skill mix is looking sufficiently at the potential health promotion benefits with the use of more DCPs, which could result in longer term cost savings. When hygienist and hygiene-therapists are considered for their contribution to a dental practice, studies have mainly focussed their economic contribution (Linna et al., 2003, Beazoglou et al., 2012). Whether these are the ideal measures of efficiency in a discipline where the need for care is diverse, and inequalities are rife, is worth inquiry. Harris and Sun (2012) highlighted the need to consider the value of the output in conjunction with the human values. They outline values such as social aspects of work, wages, the pace of work (Harris and Sun, 2012a). In their study of the views of dental practitioners on concepts of efficiency related to the use of dental therapists, Harris and Sun (2012) found that practitioners not only

highlighted income, but also patient satisfaction and health improvement as a concept of efficiency (Harris and Sun, 2012a). It is argued here that more reflection on the role of DCPs in prevention is necessary.

Third, although dental hygienists and therapists are working within the NHS, national data do not record or report their roles in delivering care (NHS Education for Scotland, 2014), and this is a major gap in the information on dental care professionals.

Fourth and finally, the contribution that the nature of care, provided through skill mix, could provide significant overall health improvements has not been widely examined. Bailit et al (2012) who compared the oral health of children in two developed countries (USA and New Zealand), where in New Zealand hygiene-therapists provide most care to children, and in the USA this is not the case. Their study showed significant differences existed in the oral health status of children of the same age-group between the two countries (Bailit et al., 2012), with the children in New Zealand having better oral health. However, these findings should be considered cautiously due to the possibility of the ecological fallacy. A recent review of the use of dental therapists in remote or rural areas by Freeman et al. (2013), has shown that there is lack of empirical evidence of the effectiveness of dental therapists in those settings.

Richards (2013) commenting on the Cochrane review (Wright et al., 2013) which proposes more research, as Wright et al (2013) found limited evidence of the effectiveness and cost-effectiveness of dental auxiliaries following a systematic review of 18 observational studies. There were no significant differences in disease volume, in places where dental therapists work. Richards (2013) proposes that the contribution of both personnel as equal, but due to the shorter training time of dental therapists it makes more sense to increase their utilisation (Richards, 2013). This does relate to health promotion, but could also link into services that are provision of care that has been proven to have significant positive impact on oral health, such as fluoride varnishing in children. It is suggested that exploring DCPs roles in providing care such as fluoride varnish is a step in attempting to outline their role in overall patient outcomes for the variety of patient groups with their diverse needs.

It is proposed in this research that there is a need to understand the potential for skill mix through the consideration of the contributions various members of the dental team can make to



meeting changing patient needs and improving overall patient health. This is accomplished by using an approach that acknowledges the multifaceted determinants of patient needs. Operational modelling techniques and scenario testing, have been used to assess the skill mix needs in older patient by Gallagher et al (2010) and their work is an example of the consideration of a variation of the value of outputs for a particular group (older people). In one scenario, Gallagher et al (2010) considered increased demand for dentures in the future as a result of an ageing population. This approach has been described as a global goal of efficiency, where one considers the needs of the recipients of care (Liu, 2003). Undoubtedly, economic aspects of service provision are important in times of finite resources, but proper economic perspective requires assessment of the population needs and the complex nature of health service production (Swedberg, 1995, Peacock et al., 2001).

### **2.8.7 Summary**

This section has defined and debated the benefits of skill mix in general health globally, as well as dentistry within the UK. It has highlighted the gap in information on contribution of DCPs to health and health services. It is important that opportunities to examine practice are used to examine the contribution of different team members to primary dental care.

## **2.9 Workforce planning for health**

### **2.9.1 Introduction**

This section considers examples of planning in relation to human resources in health, relating these to the concepts of an encompassing approach to planning the health workforce as proposed in this research. The predominant workforce plans that have been undertaken in dentistry are also unpacked for their constituents, and research explored to inform workforce planning.

### **2.9.2 Methods of workforce planning in health**

Usually, the methods chosen to estimate human resource requirements reflect the political and economic choices and social values that underlie a particular health care system (Dreesch et al., 2005). There have been four predominant workforce planning strategies for health workers: needs-based approaches, utilization or demand-based approaches, health workforce to population ratios, and the target-setting approach (Hall, 1978, Markham and Birch, 1997, Dreesch et al., 2005). Apart from health workforce to population ratios, all the other strategies attempt to translate the required number and type of health service into time-estimates which are converted into whole time equivalents (Dreesch et al., 2005).

The predominant workforce planning strategy for health services has been the calculation of the clinician to population ratios which is also recognised globally (Segal and Bolton, 2009). This type of planning has been common because clinicians constitute the most numerous personnel group and the most financially costly element in every national health care delivery system across the world and simple ratio calculations are fairly cost-effective to carry out (World Health Organization, 2000, Masnick and McDonnell, 2010), but in countries where data are unreliable this may be misleading. Although useful, clinician population ratios fail to include the complex contributors to service demand, failing to provide detail of the nature of skill required to meet the demand on health services and any other system factors contributing to demand (Segal and Bolton, 2009, Segal et al., 2008, Zurn et al., 2004).

As the contributors to demand and supply increase, there has been a need to have more complex approaches to workforce planning and improvements suggested on the other time

based approaches (Swedberg et al., 1993, Swedberg, 1995). There are several shortcomings of the various workforce planning strategies. According to Dreesch (2005) in the needs based approach the assumption is that all the needs must be met and it ignores the cost-efficiency of resource allocation. The utilisation based/demand based approach assumes the status quo will be maintained and, similar to the needs based approach, extensive data is required, the service targets approach can have potentially unrealistic assumptions on productivity (Segal and Leach, 2011). Finally, the adjusted service target approach, although it provides flexibility in allowing opportunities to look at different combinations of skill and staff, it requires time estimates from expert opinions (Dreesch et al., 2005). It is recommended that workforce planners should undertake scenario modelling, workforce costing and supply-side projections (Segal et al., 2008, Imison et al., 2009, Segal and Bolton, 2009, Segal and Leach, 2011). Also, future projections should include changes in the number, pay and mix of staff, in order to give employers and policy-makers the information they need to help improve productivity (Imison et al., 2009).

The WHO in their six-step framework (World Health Organization, 2007a) introduced similar components to health workforce planning, which included model components' such as population needs present and future, the clinical workforce to serve it, and the workload generated by both the population and the clinical workforce; such is the case with the Masnick and McDonnell model (Masnick and McDonnell, 2010). In this model the clinical service demand is a separate model and planning for this is not effectively done through attention to numbers only, but to skill mix within the workforce, and this affects appropriate deployment of clinical services enabling staff to do their work (Masnick and McDonnell, 2010). Additionally, Seagal and Bolton (2009) describe a demand model to estimate the community-based primary care health workforce consistent with the delivery of best practice chronic disease management and prevention. Such developments are encouraging as the system strives to achieve better outcomes from services.

It would appear that from most contemporary commentators there is a need for reorientation of workforce planning towards flexible models that allow alternative scenarios for the health workforce to be tested, recognising the diversity of need and skill required to meet demand.

### **2.9.3 Workforce planning in primary care dentistry in the UK**

Planning for the workforce in dentistry in the UK primarily, has considerably involved primary care, as 90% of dentists are NHS independent contractors (Department of Health, 2012a). In planning for the dental workforce, similar approaches to those employed in general health are used, however, more commonly forecasting techniques have been employed (NHS Education Scotland and Information Services Division, 2004, Robinson et al., 2011, Scottish Government, 2002, Scottish Government, 2010).

According to the Joint WHO/FDI Working Group established in 1982, planning for the manpower requirements within dentistry is more complex than dentist to population ratios (The Joint Working group of WHO and FDI, 1989). The planning models developed by the FDI and WHO included components on the oral health needs in communities, available workforce and oral health training requirements (FDI World Dental Federation and World Health Organization, 1989). This model was developed as a 'one size fits all' model in order to allow different countries to adapt the model depending on their unique situation. For example Lebanon utilised the model provided by WHO/FDI (FDI World Dental Federation and World Health Organization, 1989) and found that urgent measures were needed to reduce the potential oversupply of dentists in this country (Doughan et al., 2005). The model is flexible, and can be used by low, middle or high income countries, allowing either under or oversupply to be modelled (Morgan et al., 1994).

Some countries have further adapted the WHO/FDI model for planning dental services, adding sub-models to fit the components deemed as influential to their population. An example is the Netherlands, where a study sought to plan for the dental workforce in 25 years, based on policy and oral health needs and provided a clear country tailored example of the system factors involved in dental workforce planning (Burgersdijk et al., 1994). Burgersdijk et al (1994) used sub models of population, dental attendance, disease, treatment and supply and allowed planners to factor in the contribution of each of these parameters to the demand and supply of services. Models such as this allow scenario testing, which is a technique used to forecast change in supply in cases where model components vary; a technique proposed as useful by

FDI and Centre for Workforce intelligence in England (FDI Dental Practice Committee, 2005, Imison et al., 2009).

In order to establish the need for workforce planning strategies, a sound understanding of the literature around workforce needs in the given country are described as useful (Defriese and Barker, 1982, Maupome et al., 2001). Maupome et al. (2001) conducted a systematic review that investigated whether there was a sound basis for deciding how many dentists should be trained to meet the dental needs of the Canadian population; they reported the importance of considering the needs of various age groups of the population, cultures and cost viability of different alternative options. In addition, they also recommended the importance of updating planning strategies based on changing trends in technology or improvements in planning techniques.

Within the UK, there are workforce planning examples from Scotland that show a systematic process that progressed over four cycles. These workforce plans were reported in documents between 2002 and 2014. The first workforce cycle (Scottish Government, 2002), was a stock and flow of dentists planning model. Forecasting was used to ascertain the supply of NHS General Dental Practitioners in future years. The supply was based on the number of dental undergraduates within institutions intake rates, number of working professionals and possible retirement times.

The second Scottish dental workforce planning cycle built on the first and was reported in 2004. This cycle first analysed the utilisation of dental services in Scotland. These findings were subsequently used to forecast the demand for NHS general dental practitioners (GDPs) based on population estimates and dental registration patterns (NHS Education Scotland and Information Services Division, 2004). The third cycle (NHS Scotland, 2006) was an update of the NHS GDP demand and supply forecast of 2004. This report was propelled by the policy changes outlined in 'the Action Plan for Improving Oral Health'(Scottish Executive Health Department, 2005) and 'Modernising NHS Dental Services in Scotland (The Scottish Government, 2003). Those Government documents outlined the targets for NHS dentistry and oral health in Scotland. The 'Action Plan' also included consultations on the importance of the whole dental team, skill-mix maximisation and working with educational partners to realise the

goals for Scottish oral health. The third cycle therefore conducted investigations on the role of DCPs and outlined ways in which therapists could increase the output of a GDP. The findings suggested that therapists could improve the output of dentists by 45% and hygienists could improve dentists output by 33%, if appropriately utilised in the dental team (NHS Scotland, 2006).

Following the results of the third cycle, a comprehensive fourth Scottish dental workforce report was published in 2008. It involved similar forecasts, but now included the recent trends in the oral health within the Scottish population against targets initiated in 2006. As evident, a step by step approach to the review process, allowed for the development of model plans to include all the important actors on the workforce.

After the workforce report in 2008, the Scottish Government conducted a strategic review of the dental workforce in 2010, with a specific focus on dental care professionals, having realised the potential gain of utilising skill mix (Scottish Government, 2010). This review explored the use of skill mix in meeting the future demands on the dental workforce, but highlighted the significant gaps in information on the labour market outcomes of DCPs. The review revealed the lack of utilisation of DCP's skills within their scope of practice and further emphasised the findings from earlier reports on the benefits of delegation of duties and skill mix maximisation (Scottish Government, 2010). The most recent dental workforce report for Scotland (NHS Education for Scotland, 2014), revealed an expected increase in demand for GDPs; however, it highlighted that this does not factor in the possible contribution of dental therapists, as regulations allowing them to claim NHS GDP remuneration have not been amended. The report, like the previous reports, maintains that there is still a lack of information on DCP's contribution and recommends more research evidence of DCP's workforce labour outputs.

In England, dental workforce planning has been influenced by similar factors as in Scotland and other European countries namely: policy, dental service delivery and oral health needs of the population. Primary dental care workforce planning is supported by the efforts of Health Education England (HEE) (Health Education England, 2013). At the start of this doctorate research HEE had not taken full responsibility for the training and education of the health workforce in England; this happened in April 2013 (Health Education England, 2013). In the

past, the NHS National Workforce Projects produced workforce planning documents for various areas in healthcare and the packs were prepared for PCTs, workforce planners, academics and institutions involved in workforce planning (NHS National Workforce Projects, 2006).

The Dental Workforce: resource pack was a guide to planning the dental workforce; it held similar strategies employed nationally and internationally (NHS Education Scotland and Information Services Division, 2004, FDI World Dental Federation and World Health Organization, 1989). The resource pack took into account public health policy priorities, changing demography, age of the workforce and flexibility of skill within the dental workforce (NHS National Workforce Projects, 2006). The framework included a six-step process

[1] Define a plan

[2] Determine forces of change

[3] Assessing the demand

[4] Assessing the supply

[5] Develop an action plan

[6] Implementation and review (NHS National Workforce Projects, 2006)

The pack provided an opportunity for interested academics, government bodies or independent consumer interest groups to attempt to plan or forecast workforce requirements.

When Gallagher et al. (2010) modelled the future skill mix requirement to meet the demands of older people in England to the year 2028 (Gallagher et al., 2010), the use of operational research methods facilitated scenario development and testing of skill availability against future demand. The model suggested that there was a need to widen skill mix, and they demonstrated how dental care professionals could play a major role in building dental care capacity for older people in the future. This approach, which engages the concept of need/demand and available skill mix supply (Kleinman et al., 2009, Gallagher et al., 2010, Harper et al., 2013) and has been used in regional workforce analysis (Gallagher et al., 2013) has much to contribute to informing workforce planning.

The most recent workforce planning exercise in England has been undertaken by the Centre for Workforce Intelligence (CfWI) (Centre for Workforce Intelligence, 2014a), who were commissioned by Health Education England (HEE) and the Department of Health (DH) to

forecast and analyse the future supply of and demand for the English dental workforce between 2012 and 2040. The main purpose of this work was to contribute to information regarding the number of dental students who would require training. The approach taken was 'principal projection' or 'expected future' supply and demand. It was informed by a Delphi panel exercise and included the use of data on trends in oral health. The modelling used previous horizon scanning and scenario generations from 2012 (Centre for Workforce Intelligence, 2012). The review finds that there will be a surplus in the supply of dentists in the future in the range of 1000 and 4,000 dentists by 2040 (Centre for Workforce Intelligence, 2013).

### **2.9.1 Summary**

This section has highlighted the role of workforce analysis to inform developing the shape of the health workforce. At present, dental workforce planning in developed countries is using forecasting techniques and scenario planning. The challenge with these techniques is the accuracy of the base-line data. There is a gap in terms of real life data of use of skill mix, with an opportunity to further relate this to the type of demand/ needs of patients. In the next section a critique of strategies to promote dental skill mix is provided.



## **2.10 Contemporary methods of dental training and research in primary care**

### **2.10.1 Introduction**

Education and training provide the first step towards preparing health workers. Often the ways of practice learned are carried forward into career practice. As the literature has highlighted the nature of need and demand the future workforce will need to tackle and the organisational environment to be expected in primary care is changing and the training the emerging dental professionals obtain is the first step or preparation. Educators have devised training strategies that promote teamwork and an understanding of the diversity on needs (Health Education England, 2014a). In an attempt to create a workforce that is needed, HEE has proposed a review for dentistry that would likely reduce the number of funded dental undergraduate places and increase the focus on the training of DCPs (Health Education England, 2014b). In addition, several strategies to improve undergraduate learning in order to integrate the training of dental professionals and prepare them for real working environments have become a part of the GDC requirements (General Dental Council, 2012). In this section some of the strategies are revealed and their implications to working practice through research evidence are highlighted. This section also highlights the gaps in knowledge within these contemporary methods of training.

### **2.10.2 Interprofessional training**

Interprofessional education occurs when two or more professions learn with, from and about each other to improve collaboration and the quality of care (Freeth et al., 2005). According to Meads and Ashcroft (Meads et al., 2005) being a health professional today is to be interprofessional. The WHO has provided the most influence towards interprofessional education through policy documents (World Health Organization, 1987, World Health Organization, 2013a), supporting the use of interprofessional education in the training of health workers so as to improve collaboration. Educating professionals in an environment that involves collaboration has been suggested to lead to collaborative practice (Meads et al., 2005).

The UK is one of the most advanced countries in terms of interprofessional training, with organisations such as the Centre of Interprofessional Training (CAIPE), an independent body in

partnership with Health Education England, providing frameworks and conducting numerous studies on the establishment and evaluation of interprofessional training programmes in the UK and overseas (CAIPE and Department of Health, 2007).

Clifton et al. (2006), considered the key elements of interprofessional education as 'team work', 'patient satisfaction', 'skill mixing', 'flexible working' and 'opportunities for new career options'. In addition, interprofessional training contributes to increased flexibility and capability of the various skill groups (Clifton et al., 2006). The International Association for Medical Education (IAMR) describes interprofessional learning as being as important as the knowledge of diseases, because it provides experience of the work environment professionals will face on graduation' (Harden, 1998).

There is little quantitative research on the impact of interprofessional training most of the work has assessed views of health workers involved (Larkin and Callaghan, 2005, Morison and Jenkins, 2007, Morison et al., 2008). The majority of the studies have only shown the influence of interprofessional training on collaboration in teaching soft skills, communication and professional identity. In dentistry in particular, evidence is lacking on the impact of interprofessional training on hard skills such as task sharing, as required for skill mix and teamwork (Reeson et al., 2013).

Reinders and Blanksma (2012) undertook a study in the Netherlands, 'The collaboration between dentists and dental hygienists: from paradox to resolution,' which investigated the processes of task sharing between dentists and dental hygienists. They found that there are four aspects that influence collaboration and the acceptance of vertical task redistribution:

- 1] The transition from a hierarchical work relation to a more functional work relation,
  - 2] Educational level as related to competence and social status,
  - 3] The relation between vertical task redistribution and professional identity
  - 4] The perceived usefulness of interprofessional collaboration and task
- (Reinders and Blanksma, 2012).

These ideas suggest a need to understand each other's roles better in order to collaborate and share clinical tasks. Reeson et al. (2013) highlights that although evidence suggests

communication improves in interprofessional training, more research into hard skills and impact of interprofessional training beyond universities is required.

UPDA's integrated learning is based on interprofessional education and ascribes to Barr's (Barr, 1998) definitions of interprofessional education, which is a collaborative process that provides members of the different professions with an opportunity to understand each other's roles and operations, while meeting requirements of their duties. If Reinders and Blanksma (2012) are right, the interprofessional learning environment of UPDA may encourage a form of task sharing and optimise skill mix. This research attempts to explore this.

### **2.10.3 Outreach training and the dental team**

Although the DCPs at UPDA are undergoing their normal training at the Academy, for the KCLDI students UPDA is their opportunity to experience outreach training. The dental students spend 3.5 days working in the clinic in a primary care set-up, to prepare them for work in General Dental Practice as a Dental Foundation Trainee. Dental outreach is a fundamental part of the GDC and European dental training prerequisites (General Dental Council, 2009a, European Ministers of Education, 1999, General Dental Council, 2012). Outreach training has been shown to provide benefits to the working practice of the students during their training by improving skill and confidence. (Elkind A, 2002, Smith et al., 2006c, Eriksen et al., 2011).

A randomized controlled trial by Smith et al. (2006c), which compared the effects of outreach placement with traditional exclusively dental school-based clinical experience, found that outreach training significantly increased students' confidence in providing everyday dental care for patients which was linked with increased competence. This increase in confidence and competence exhibited by outreach-trained dental students, has also been reflected in qualitative research by Eriksen et al. (2011) who found that skills gained as a result of in outreach improved communication, team working, increase of awareness of roles and responsibilities of team members, clinical and decision-making abilities.

The practice of community outreach training for dental students is common in the UK, as evidenced by an extensive study of 14 models of outreach training in the UK and Ireland (Lynch et al., 2013). Lynch et al. (2013) found that the community based teaching did provide good preparation for vocational training and subsequent working lives. With these findings it is

reasonable to expect that research into UPDA's environment may give a glimpse of their future practicing routine.

#### **2.10.4 Research in primary care and electronic records**

UPDA and its predecessor organisation, SPCD, have been primary care providers. Although it is primarily an educational environment, any research undertaken in this setting does constitute primary care research. The Department of Health is encouraging primary care research, and the Clinical Commissioning Group and the National Institute for Health Research (NIHR), have consequently expanded the scope of research funding to themes that relate to primary care (National Institute for Health Research, 2013). As of 2013, reports state that more than half of all primary care sites in England were actively engaged with at least one NIHR portfolio study in the preceding five years and the majority of these are medical sites (Mosedale and Wallace, 2013). Medical colleagues may have advanced capabilities to perform research in primary care, due to the support of central general medical records which have codes (Gulliford et al., 2009). Still, dentistry has opportunities to learn from medical colleagues and to harness the wealth of data in primary care patient records and to participate in primary care research.

#### **2.10.5 Electronic patient management system data in research**

The volume of activity and the number of patients managed in primary care is high, because the majority of people use this as their first point of contact with the system. The amount of data collected through health records in the primary care system is variable and voluminous. All the data collected could potentially hold information to help improve service or patient outcomes. In conducting primary care research, traditional patient and clinician recruitment can be a cumbersome process in the highly dynamic environment. The cost of time away from duties for clinicians and patient follow-up can be a limitation to the amount of research that can be undertaken. Research using patient records is an alternative to the arduous traditional methods of data collection. Electronic patient management data which are a form of 'big data' are a hub of rich data described as the 3 Vs of big data; volume, variety and velocity (Raghupathi and Raghupathi, 2014).

Patient management systems were developed to manage health records for administrative purposes (Anderson, 1997). They have since been further envisioned to integrate clinical

activity, administration and financial systems in order to improve patient care (Bose, 2003). The primary function of health records collected in patient management systems is to document the needs and the care patients receive over time, in order to facilitate communication between providers (Eggleston and Klompas, 2014), although more recently, the inclusion of decision support software within these systems has been shown to improve both clinical outcomes and adherence to evidence-based guidelines (Vikram and Karjodkar, 2009).

Leake and Werneck (2005) examined the potential for research using administrative databases containing dentists' claims highlighting this as an underexploited area of research. They stated that studies analysing administrative databases have the advantage of size and economy but are subject to validity issues (Leake and Werneck, 2005). Kudyakov et al (2012) suggest validation of electronic data with external data sources provides a way to validate the data. Leake and Werneck (2005) suggest that the strongest designs occurred with investigation of the longevity or consequences of care and those studies demonstrated the benefit of linking the service data to patient or provider characteristics. Another interesting aspect of Leake and Werneck (2005) was that they were able to link provider characteristics to care. These findings support the potential for similar utilisation in this study of skill mix, as the data allowed provider characteristics (student professional group) to be linked to the care they provided which is a description of skill mix.

In a technical sense, electronic patient data in research according to Grant et al. (2006), have two primary functions; analytic function (information processing) and clinical action (capacity for provider and patient intervention). They propose that the analytic functions allow providers to define and stratify patient risk factors through cross-sectional analysis or creating longitudinal registries (Grant et al., 2006). Eggleston and Klompas (2014) go further to suggest that the findings from the analytical studies performed on patient management data can be used to support the 'doing' functions of population management, such as clinical decision support, team-based care, patient and family engagement, integration of care and care transitions across sites, and targeting of disparities (Eggleston and Klompas, 2014). All these provide a foundation for research questions relating to how health workers contribute to care.

One of the challenges of any type of research is to identify and limit biases throughout the research process (Pannucci and Wilkins, 2010). Despite the fact that patient management systems are subject to issues of validity (Leake and Werneck, 2005), using these data can limit recall biases and low response rates. These data are a hub for information on the pattern of the activities conducted by health workers. So far, research using primary care patient management systems has facilitated research on guidance compliance, diseased patient identification (Hogan and Wagner, 1997) and general clinician practice (Ashworth et al., 2004).

Skill mix research in the UK can benefit from patient management data as these data include information on the practice patterns of different health care providers. Leake and Werneck (2005), demonstrated that patient management data can facilitate linking of care and provider characteristics. This type of data can add knowledge on how different team members can contribute to the care of a variety of patient groups, filling a gap in knowledge that has been highlighted in the UK, regarding the lack of data on labour outcomes and activities on health worker groups such as DCPs (Scottish Government, 2010, Harris and Sun, 2012b).

#### **2.10.5.1 Electronic patient data structure**

The data in these patient management systems are stored in either narrative or structured form or both (de Lusignan and van Weel, 2006). The quality of the data is largely dependent on the compliance by the systems' users to accurately update the system (Leake and Werneck, 2005). However, challenges do also exist in obtaining non-codable data such as free text, and natural language processing has not developed to a point in which coded data can be replaced (Chapman et al., 2005, de Lusignan and van Weel, 2006). Coded data is not standardized, and it is important to ascertain the quality of the data collected in a primary care setting before using it for research (Scobie et al., 1995). It has been proposed that in order to improve data quality assessment, guidelines should be put in place (Van Weel-Baumgarten et al., 2000).

A systematic review of data quality measurement tools showed variation in methods of data quality assessment methods (Thiru et al., 2003). The review highlighted the need for more standardised measures of quality; it also highlighted the low maturity of the area as most of the

work had been carried out in the late 90s (Thiru et al., 2003). As patient management systems become more sophisticated, they become a richer source of information and therefore more focus on improvement of data quality is necessary.

#### **2.10.6 Summary,**

Contemporary methods of training the dental team are ongoing at UPDA. The literature suggests that these strategies of interprofessional education and community outreach are responsible for improving teamwork. UPDA, which is a primary care environment, manages a diverse patient pool and using their information management systems which can be useful in the monitoring of activities and patient population profile, factors would provide reasonable insight into teamwork and primary care. Considering that the research on these contemporary educational strategies is limited and the same applies to skill mix research in primary care, there is a possible benefit to researching this site. In addition, the growing understanding and use of routinely collected patient data for research is an additional avenue along which to conduct robust detailed research.

## **2.11 Summary of the literature**

### **2.11.1 Primary care**

Primary care is central to the delivery of healthcare globally (World Health Organization, 2013b) and nationally (National Health Service, 2014). The importance of research in relation to state funded health care is patient driven and should lead to improved outcomes (Department of Health, 2010a). For dentistry as well, the majority of services are provided through primary care services and the prevailing message is that the dental workforce is expected to be flexible and the skill mix to be orientated in the face of changing needs and service reforms (Department of Health, 2011a, Department of Health, 2012a).

### **2.11.2 Drivers for change**

The drivers for change in primary dental care and therefore human resources for health include the shift in the patient population's needs, associated with improving oral health, an ageing population and tooth retention. Not all changes in oral health have been positive, as England is also experiencing widespread inequalities in oral health. There is impetus to adequately monitor changes in demands using technology in order to appropriately plan with a clear understanding of need. The role of dental services is to tackle needs and demands based on social change (Department of Health, 2012a). It is now more important than ever to consider how best to cater for expected changes in need, which are unclear; perhaps more prevention for the ageing and more complex care to maintain the longer retained teeth (Brocklehurst and Tickle, 2011b). Certainly evidence based care which involves prevention for children, in order to provide them with a favourable start, is one of the key priorities (Public Health England et al., 2014). It is also a prevailing question in dentistry, how best to ensure effective access to services in order to provide evidence based care (Currie et al., 2012, Harris, 2013). In one way improving capacity and promoting organisational ways in which the dental team works together in primary care is a fundamental part of this plan.

### **2.11.3 Human Resource for Health**

There is great emphasis on creating a health workforce capable of meeting desired outcomes in the face of the current needs (World Health Organization and Global Workforce Alliance, 2014). The skills required of the dental team may have changed and a flexible approach to the



practices of the dental team is required in order to maintain the health of the population (NHS England, 2014a). The literature review has identified that the goal to improve dental team collaboration is in line with plans to meet the current change in oral health needs. There is, however, a jurisdictional contest between the different dental professionals groups; DCPs and dentists; concerns with safety and quality of DCPs services have no founded evidence and the outcomes of training for dentists and DCPs, as outlined by the General Dental Council, are similar and the same level of professionalism is expected of all dental team members (General Dental Council, 2011). Furthermore, there has been a widening of the scope of practice of DCPs to facilitate more involvement in the care of patients (General Dental Council, 2009b, General Dental Council, 2013b) and most recently patients can directly access DCPs (General Dental Council, 2013a). Even so there are still significant areas that lack clarity on how to include the widened scope of DCPs in primary dental care (Wake, 2014) and to DCPs and dentists can work together.

#### **2.11.4 Education and training**

Therefore, a primary goal for both policy and regulatory authorities in England has been to provide training and education that embodies collaboration early on for members of the dental team (General Dental Council, 2011, Department of Health, 2012a). Interprofessional training has been described as a fundamental part of this agenda (Medical Education England, 2011). It is suggested that it encourages the collaboration and the use of skill mix working patterns. More task delegation and role substitution is shown to be a way to reorganise health workers to work as teams and meet needs. This essentially constitutes improved use of skill mix, a concept widely practised globally and for which the dental profession lags behind medical colleagues.

At the present juncture, health policy documents in England are in support of more skill mix and teamwork (Department of Health, 2010b, Department of Health, 2012c, Department of Health, 2012b, Department of Health, 2014a). Unfortunately, the literature suggests that maximum utilization of the skills of DCPs is still not occurring. Misconceptions regarding the role of DCPs and economic arguments have prevailed (Gallagher and Wright, 2002, Ross et al., 2007a, Ross et al., 2009) as well as jurisdictional debates/attitudes (Holden, 2012). All these factors point to a lack of understanding of the organisation within the dental team and support a need to provide

clearer guidance on how this skill mix can be efficiently instituted (Centre for Workforce Intelligence, 2014b).

There is a lack of management information on DCPs especially in primary dental care, which is the main point of service (Harris and Sun, 2012a, Brocklehurst et al., 2013). Furthermore, there is insufficient information on their productivity within primary dental care (Scottish Government, 2010, Sun and Harris, 2011) as well as major gaps in understanding how the dental team skill mix can be used in achieving positive outcomes for patients and how each member can, and does contribute (Swedberg, 1995).

Contemporary training and education strategies together with evidence based primary care are the main issues which lead to promotion of skill mix in both the general and dental workforce. An example of one approach is UPDA, which is training professionals who will emerge as the new dental workforce in primary care together as a team. The facility has been described as an environment where students are trained as a team with a desire for trainees to develop teamwork and carry it forward into their post-qualification practice. This environment displays the potential to aid in identifying the contributions of various members of the dental team within a team based model primary care model. The potential for research to explore how real health needs are met within skill mix within a high needs area is present through the case study of UPDA. The literature supports interrogation of the robust primary care data and activities and using modelling techniques knowledge can be advanced on how skill mix learned in undergraduate team training, can be translated into practice in primary care.

#### **2.11.5 Use of routine data**

Data routinely collected in primary dental care contain rich information on patients and their journey through the system. Leake and Werneck (2005) highlighted that this is an underexploited area for dental research. The ability to save time, by obtaining large data sets, could aid answering health service questions; subject to use of stringent validation strategies. In wider health research, routine data has been validated using external records, comparison with parallel data collection (Hogan and Wagner, 1997) and comparison of general clinician practice data with national survey data (Ashworth et al., 2004). In UPDA, the patient management system collects data on patient socio-demography, treatment activity and provider of care. The

potential to understand who is receiving care and where expressed treatment need is high with this data. In addition the ability to ascertain who provides care, can facilitate research on the contributions of different members of the dental team to treatment.

## **Chapter 3 Aims and Objectives**

### **3.1 Aim**

The aim of this research was to investigate the patient base, treatment activity and skill mix practice at a primary dental care team training centre prior to, and after, its establishment, and to model the potential for skill mix use in national primary dental care based on the undergraduate training experience in this centre.

### **3.2 Objectives**

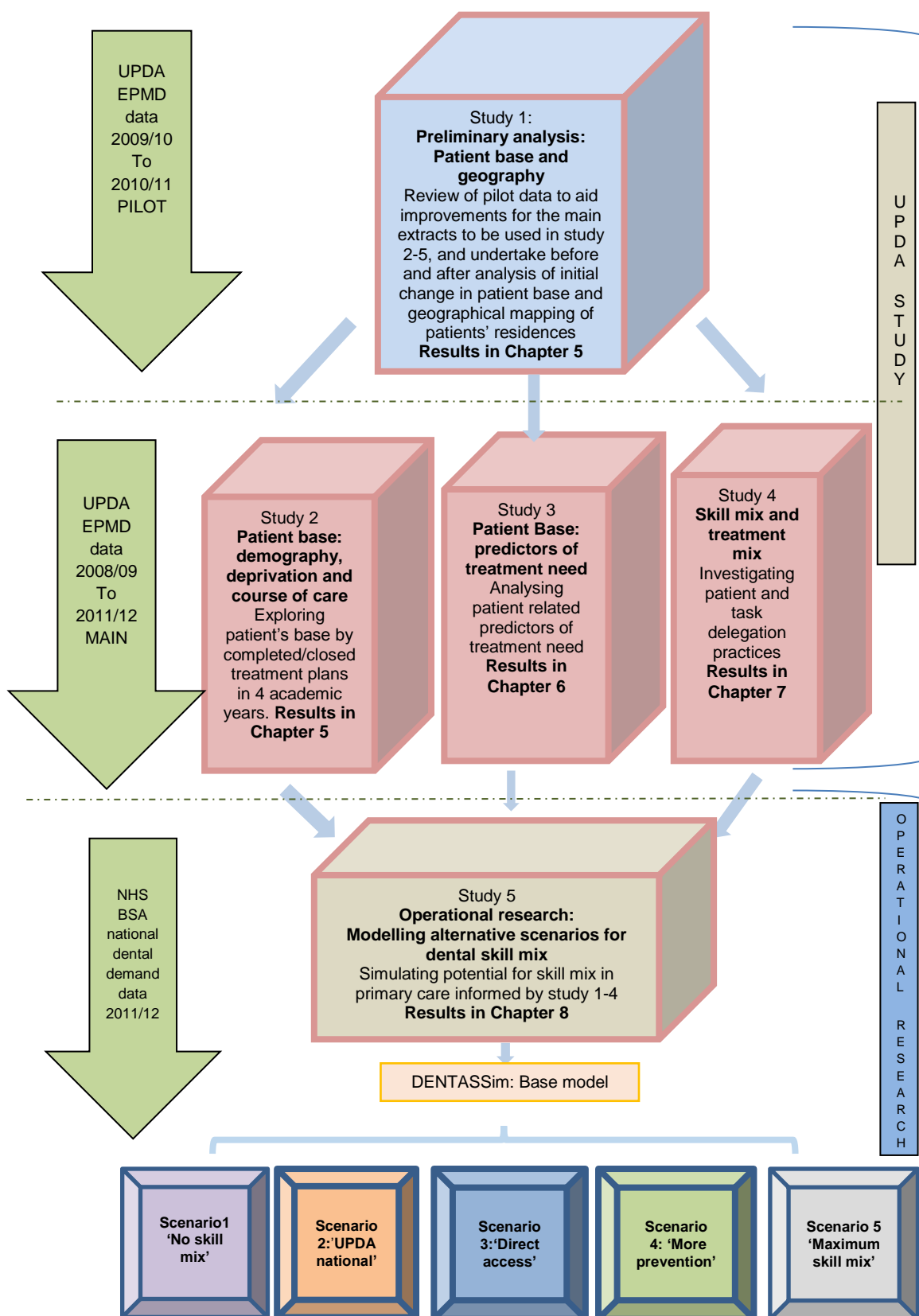
- 1) To describe the patient population accessing a primary dental care training establishment in terms of demography, deprivation and geographic area of residence before, and after, the start of team training and the expansion of services.
- 2) To investigate the relationship between patient socio-demography and treatment received during courses of care and over time.
- 3) To examine the skill mix practice at UPDA in relation to patient socio-demography and treatments provided during team training.
- 4) To examine the implications of findings from team training experiences for primary dental care nationally and test the potential for skill mix utilisation within NHS dental care.

## **Chapter 4 Methods and methodology**

### **4.1 Introduction**

This chapter provides the rationale for the methods employed to meet the aims and objectives of this research. The chapter includes a description of the research methodology and a debate of possible alternative methodologies. Thus, the benefits and limitations of the methods employed are highlighted. Figure 4-1 is an overview of the studies. The chapter is organised in two sections. Section 4.3 describes the first part of this research, which was a case study of UPDA undertaken on patient management data. This includes sections on the processes of data extraction (Section 4.3.3), cleaning and validation (Section 4.3.5) and descriptions of augmented data sets and additional data used to support the analysis (Section 4.3.8). Section 4.4 is the second part of the chapter which provides a sequential outline of each of the four studies undertaken as part of UPDA data analysis. Section 4.5 is the third part of the chapter and describes the second part of this research. In this section the rationale for the operational research strategy, which was employed to model findings from the case study of UPDA and alternative scenarios for skill mix on to national primary dental care are provided.

## 4.2 Research Methods overview



Note: UPDA EPMD – University of Portsmouth Electronic Patient Management data; NHS BSA – National Health Service Business Service Authority; DENTASSim – Dental Treatment and Skill Mix Simulation Model

Figure 4-1 Research Methods Overview

## **4.3 An analysis of UPDA patient information**

### **4.3.1 Introduction**

The analysis of patient information from UPDA was the first part of the research process. The research methods involved the design of a strategy that would obtain data, which could be interrogated and analysed to gain a comprehensive understanding of the patients and treatment activity at a primary dental care training facility. The data from this analysis were to inform operational research on the potential for skill mix in national (England) primary dental care described in Section 4.5.1.

UPDA was considered ideal for a study of this nature as it could generate, useful learning on integrated practice in primary dental care. Single site study (Bergen and While, 2000), allows the investigation of phenomena at a micro level and provides an opportunity to generalise and test identified theories onto a macro level (Yin, 2009). The research involved the investigation of the relationship between patient characteristics, expressed treatment needs, and the ways in which skill mix was used to meet patient needs by these emerging dental professionals training at UPDA. A parallel programme of research ongoing at UPDA, involves in-depth research on the attitudes, experiences and beliefs of students and the educators on the team training process, using qualitative methods. The two programmes of research complement each other by contributing to an overall understanding of the undergraduate learning experience at UPDA, but with varied perspectives. Specifically, the qualitative research explored what they say they do, and this current research investigated what they actually do.

#### **4.3.1.1 Use of electronic data in the research design**

The research was undertaken using data extracted from the facility's patient management system. The data extraction process was iterative and involved consultation with the software developers, in order to ensure robust and reliable quantitative data. Data were extracted in two phases, first, a pilot extraction and second, a main data extraction. The pilot informed a more robust second main extract and primary analysis of the data. Stringent data cleaning and validation processes, explained in Section 4.3.5.2, were undertaken to further ensure integrity of the data. In addition, survey data from National Adult Dental Health Survey (2009) and the NHS

Business Services Authority [NHS BSA] were used to undertake further validation of the findings from the UPDA data at various stages of the research process.

#### **4.3.2 Alternative methodologies and rationale for use of electronic data**

##### **4.3.2.1 Introduction**

This section describes the overall rationale and process of the data extraction. It is followed by a discussion of alternative methodologies considered and the justification behind the use of electronic patient management data. The majority of the literature around the use of patient management data was covered in the literature review and reference is made to those sections where relevant.

##### **4.3.2.2 Patient management data at UPDA**

The electronic patient management system at UPDA is a rich source of information and was the same system used by the predecessor organisation. As highlighted in the literature review electronic patient management data are a form of 'big data' and are described to have 'volume, variety and velocity' (Raghupathi and Raghupathi, 2014). These data included patients' socio-demographic details, treatment data and in some cases the provider of care as defined by professional group. Identifiable data such as postcodes, were also required from the system, and a specific request to include these data was made to ethics committee with appropriate justification. The justification was the need to use these data for augmentation with other data sources in order to gain deprivation scores and geographical vector data of patients' residences, for comprehensive analysis of the patient base characteristics. The process of ethical request for these type of data involved following clear guidelines from Wellcome Trust and Caldicott (Caldicott, 1997, Wellcome trust, 2009). All the data provided an opportunity to determine the nature of service uptake, distribution of treatment need in the patient populations and in identifying where demand for care was greatest; factors useful in planning for staffing and skill requirements.

As the same patient management software was used before and after UPDA's establishment, it was possible to obtain information from both periods. Apart from software upgrades and a different contract, which increased the number of parameters for data collection after UPDA opened, the system in the period before UPDA collected similar patient details and treatment



activity information. There were particular modifications to the system to aid team training, such as treatment codes that included identifiers of the cadre of student providing care during the integrated team training period. This aspect of the system was particularly helpful in aiding to identify the provider of care for skill mix analysis. In the next section alternative methods that could have been used in place of electronic patient management data analysis, are outlined. This is followed by a brief summary of the identified benefits of the use of electronic data.

#### **4.3.2.3 Student survey**

The first alternative to electronic patient management data would be a population survey of workforce skill mix and patient care. Students and patients could have been recruited, and requested to record their treatment processes on data collection sheets. This approach is similar to Evans et al. (2007), where a cross-sectional time in motion study was used to investigate the care provided to adult patients attending general dental practices in Wales, by asking clinicians to fill data collection forms describing aspects of care they provided (Evans et al., 2007). Other researchers have used questionnaires to ask personnel to recall their activities and this has also yielded information on activity and working hours (Gibbons et al., 2000, Hopcraft et al., 2008, Godson et al., 2009, Tseveenjav et al., 2009, Robinson et al., 2011). The benefit of such a survey design is that they are prospective, and additional questions on experiences could be asked of the patients and clinicians using a questionnaire. On the negative side, this type of study would be subject to the limitations common to surveys such as sample size and selection bias (Neale, 2009); the former implying too few participants recruited, thereby limiting the strength of study, and the latter suggesting a predisposition to recruit patients who were more willing to participate and not necessarily representative of all the patients seen at the study site.

Another limitation would be the time wastage. A survey would have forced the students to take time to fill in data forms; repeating entries that had already been made electronically. Swedberg et al. (1993) undertook a timing survey using trained observers and this was a tedious process involving personnel spending lengthy amounts of time counting procedures and time undertaken; it would therefore impact on clinical time and productivity. Another challenge for a survey of this kind is that it could be subject to social desirability biases, which is where participants, in this case the students, perform as they think they are expected to perform, as

opposed to how they normally would (Grimm, 2010). Finally, prospective survey of the data from the period prior to UPDA's establishment could not be obtained by means of recall; in particular, the review of previous operations and demand would not be obtainable.

#### **4.3.2.4 Public claims data analysis**

A second alternative to the use of electronic patient management data could be the use of claims data for UPDA. In England, the NHS BSA collects the data from dental contractors who have agreements with the NHS. Commissioning authorities hold details of provider activities for which they have been recompensed. These types of data have been used to analyse trends in dental treatment in several industrialised countries (Del Aguila et al., 2002, Leake and Werneck, 2005, Guiney et al., 2013). In England, Gallagher et al. (2010) used data from the Dental Practice Board (DPB) public claims to describe the nature of attendance and NHS activity in older patients in England, and later used these data for futures operational modelling simulating future supply based on change in an ageing population. This is discussed in greater detail in Section 4.5.

Through the Freedom of Information Act (Legislation.gov.uk, 2000), data on dental activity that has been recompensed through claims can be freely requested from the NHS BSA. These data have been used in areas of research such as antibiotic prescribing research (Ashiru-Oredope et al., 2012). Although these data are free following request they have limitations and only non-identifiable variables are available through the claims data from the NHS BSA and thus exclude patient date of birth and post code. In this study, whilst NHS BSA data were used in the operational research exercise, the definitive information required for the case study analysis of patient characteristics was more suitably obtained directly from UPDA's patient management systems.

Identifiable variables facilitate in-depth descriptive and analytical research of patients and the care they received. Without post codes, augmentation to census deprivation data would not be possible, and contextual aspects of treatment need could not be analysed. This aspect of the study is explained in detail in 4.3.8.1. In brief, electronic patient management data were considered more suitable for the type of in depth analysis that was to be undertaken. And although electronic patient management data analysis is not commonly used in dental

research, the benefits of using this type of data outweighed the potential challenges. It was non-invasive to patients, time saving for data collectors and low cost (Atienza et al., 2007). Studies in wider health have used electronic patient management data and found it to produce valid data (Kudyakov et al., 2012, Lawrence et al., 2014). Several researchers have also sought to validate the data from electronic patient management systems successfully (Gimbel et al., 2011, Lambdin et al., 2012, Kudyakov et al., 2012). Schleyer et al. (2010) suggest that the growing availability of electronic data offers practitioners increased opportunities for reusing clinical data for research and quality improvement. In the following section, the data extraction process is described, from the development of the study designs and the data extraction tools.

### **4.3.3 Electronic patient data extraction process**

#### **4.3.3.1 Introduction**

This section begins by describing the patient management system at UPDA and the process of appraisal of the system. This is followed by a description of the internal structures (schema) of the data base in Sections 4.3.3.3 and 4.3.3.4. The process of developing data extraction tools (scripts) is then shown in Section 4.3.3.5. Finally, as the data were extracted in two phases, pilot and main extract, both are described and the resultant extracts fully listed in Sections 4.3.4 and 4.3.4.1 respectively.

#### **4.3.3.2 Electronic patient management system appraisal**

Before any of the data extraction phases were embarked upon, a full appraisal of the electronic patient management system user interface at UPDA was undertaken. This was in order to understand the nature of the data collected in clinic, and to ascertain whether the research questions can be answered from the data collected in the system. This technique of system appraisal is encouraged by researchers who have utilised electronic data as it aids the process of research design (Lobach and Detmer, 2007, Stephens and Reamy, 2008).

The electronic patient management system at UPDA is '**Clinical+**' developed by Carestream Ltd. The system is used by inputting patient and treatment information during routine patient episodes. This is undertaken by the dental students, DCP students and tutors. As the system is also developed for patient administration and dental contract monitoring, business managers can also access billing information sections on the electronic patient management.

The electronic patient management system logs patient details, medical history and records of treatment activity. It has a built-in care pathway, which ensures that the procedures marked as part of a course of care have to be logged as completed before the care pathway/plan is closed. Other aspects of the system ensure that patient socio-demographic details associated with billing are populated before users can open or close a patient's record, this includes age and payment status.

Before UPDA was established, an earlier version of **Clinical+** was in place. The system was upgraded two months before the expansion into UPDA. The interface seen by those operating the electronic patient management system is shown in Figure 4-2. In appraising the user interface the following aspects were considered:

- I. The type of data collected on patients and their treatment.
- II. The protocols in place for practitioners while updating the system.
- III. The interpretation of the system fields by practitioners.

Kudiyakov et al. (2012), state that understanding these aspects of an electronic patient management system is important as it ensures that the interpretation of the extracted data is correct, as users 'input-intentions' would have been established.

The screenshot displays the Clinical+ software interface for a patient named Oliver Meakin. The interface is organized into several sections:

- Header:** Displays the patient code '10000547' and 'NHS (Exempt)' status.
- Tabs:** Includes Personal, Medical, Schemes, Appointments, Financial, Comms, Notes, and Treatment.
- Personal Section:**
  - Patient Code: 10000547 (with a search button)
  - Surname: Meakin
  - Forename: Oliver
  - Patient Title: Mr (with radio buttons for Male and Female)
  - Scheme: NHS
  - Date of birth: 28/07/1994 (with a calculated age of 16 Years 4 Months)
  - Home Address: Oak Barn, Park Lane, Britford, Salisbury, SP5 4EA (with buttons for Find Address, Edit Address, Work Tel/Email, and Receive Child Letters)
  - Billing Address: Option to 'Use Separate Billing Address' with a Change button.
- Clinicians Section:**
  - Dentist: IPAG - Jim Page
  - Hygienist: No Hygienist
- Appointments Section:**
  - Last Appt: N/A
  - Next Appt: 17/12/2010 13:30
- Age Debtor Section:**
  - Current Balance: 0.00
  - 30 to 60 days ago: 0.00
  - 60 to 90 Days ago: 0.00
  - 90 + Days ago: 0.00
- Family Members Section:**

Name	Age	Relationship
Oliver Meakin	16	
James Meakin	13	
- Warning Message:** A field for entering a warning message with Clear, Cancel Edit, and Apply buttons.

Figure 4-2 Clinical+ patient management system at UPDA user interface

Source: Carestream Ltd

#### 4.3.3.3 Description of Clinical+ user interface

Clinical information was input into UPDA's electronic patient management systems through tabs on the user interface. **Table 4-1** details the titles and description of the various data tabs available on the **Clinical+** user interface

**Table 4-1 Tabs & functions on the interface of Clinical+ electronic patient management systems**

Tab titles	Description
<b>Personal</b>	This allows you to edit patient's records and holds personal details e.g. addresses, date of birth etc.
<b>Medical tab</b>	Collects information on general patient health problems, allergies, social questions on health behaviour etc. This part of the records includes a care pathways section.
<b>Care Pathways</b>	This section includes a variety of medical and social questionnaires, as well as clinical surveys to detail a patient's recall period among other elements of the care. This can be activated or deactivated depending on preference. <b>NB:</b> When the study began this system had not been activated and therefore patients were not having risk assessment or recall periods assigned based on the care pathway.
<b>Schemes</b>	This collects the administrative details required for the contract management.
<b>Appointment</b>	This allows the front staff to monitor patients waiting or cancelled etc.
<b>Financials</b>	This gives information on the costs of care.
<b>Communications</b>	This allows the administrators to send reminders and messages to patients automatically.
<b>Notes</b>	This allows additional administrative notes to be included in the system.
<b>Treatment</b>	This allows for treatment planning, charting and free-text regarding treatment.

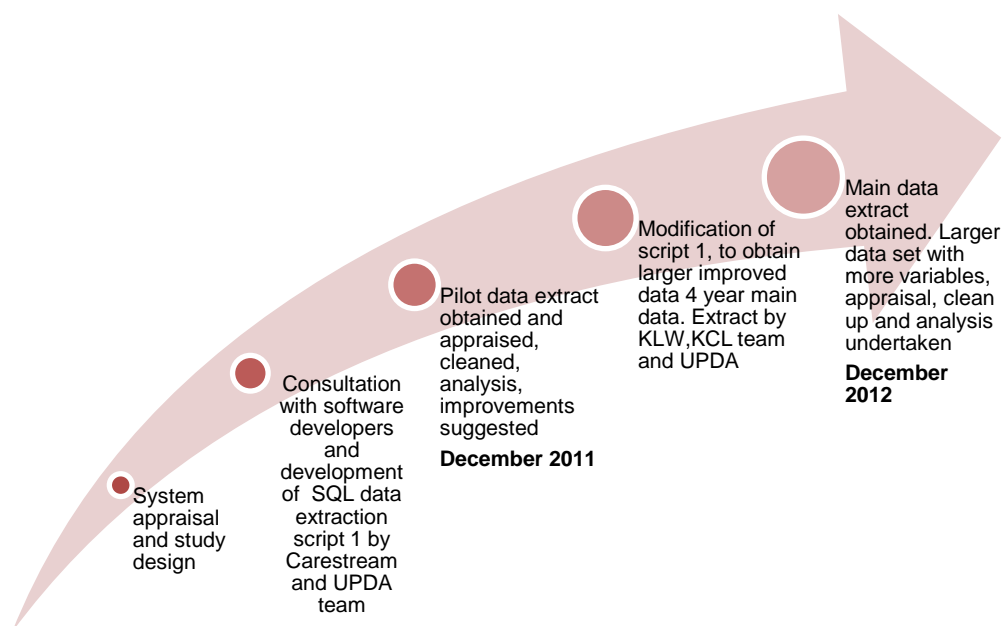
Source: UPDA's Clinical + user interface screens

#### 4.3.3.4 Data base schema

As the clinicians input information through the user interface, the database interface or the relational tables stores the data. The structure of this database/relational tables is based on a schema, which is a plan of the tables that store the data [details in Section 4.3.6.1]. The database for **Clinical+** software is in System Query Language (SQL) and includes relational tables with titles such as patient details, treatment and administrative information. Tables were linked together using unique identifiers in order to allow different information regarding one patient to be stored separately whilst allowing retrieval into one record, when required. In total there were 60 tables, which stored different sets of the data collected within the user interface. The detailed schema could not be included here due to the intellectual property regulation. Interrogation of the database was only possible through the use of an SQL script developed using the schema design.

#### 4.3.3.5 Extracting the data

Following appraisal of the software system, a data extraction tool based on an SQL script was developed. This process involved consultation with software developers. As two phases of data extraction were undertaken, the first script was modified to produce a more robust data set. Following extraction in both the pilot and main phase the data were transferred to an Excel spreadsheet. The process is detailed in **Figure 4-3**.



**Figure 4-3 Process of data extraction**

#### **4.3.4 Pilot data extract**

The first SQL script (data extraction tool) produced the pilot data. This data extraction script was written with the aid of a data request developed by the researcher following consultations with Carestream Ltd and UPDA Information Technology team. See data script appendix 10.6.6. The request for the data script was informed by literature review, appraisal of the UPDA software system and the research questions that had been developed. The script was run on 11th December 2011 and the pilot data was obtained.

The resultant pilot data contained patient data and clinician coded treatments from the management system. These data were the last completed treatment plans of patients treated at UPDA/SPCD between 1 September 2009 and 31 August 2011. The categories of patient variables requested were;

- i. Date of Birth,
- ii. Sex,
- iii. Postcodes
- iv. Ethnicity,
- v. Date of treatment,
- vi. Benefit status,
- vii. Oral health risks status (RAG rating),
- viii. Treatment plan
- ix. Procedures undertaken (some including operators).

Some of the variables were poorly populated and were not subsequently used in analysis. This is discussed in detail in Section 4.3.5.

##### **4.3.4.1 Main data extract**

The second extraction resulted in the main data set, which covered a four-year period. This second phase of data extraction was conducted in December 2012. To inform the second data extraction tool, a thorough review of the pilot data's strengths and limitation had been undertaken. This was followed by a detailed description of modifications and additions required for the second extract; outlined in Appendix 10.6.7 on page 417.

The researcher (KLW) assisted by Kings College London IT team wrote the second data extraction script in SQL; script shown in Appendix 10.6.6. The resultant data were first in excel CSV format and after preliminary clean-up, were converted to tab-separated format, then column-separated files. The files were finally changed into SPSS format for data cleaning.

The second extract had more variables than the pilot extract. It maintained all variables that were present in the pilot data, including those that had not been fully populated, but now with additional variables. Of particular importance in the main extract, was to establish a way to describe patient disease risk, as the risk variable (RAG score) in the pilot extract was poorly populated (10%). Smoking status was ascertained using the smoking cessation signposting variable as UPDA had an above 95% rate of identifying and signposting smokers to cessation services.

Another major difference between the main extract and the pilot was the inclusion criteria used for data and patients. It included all completed treatment plans in the four-year study period; meaning patients who had more than one treatment plan had all treatment plans included.

The completed main data extract can be described as all patients who had at least one completed treatment plan between 01 August 2008 and 31 August 2012. If patients had more than one treatment plan in the four-year period, all the plans were included. Categories of patient variables in data extract two were;

- i. Date of birth,
- ii. Sex,
- iii. Postcodes
- iv. Ethnicity,
- v. Date of treatment,
- vi. Benefit status,
- vii. Oral health risk status
- viii. Treatment plan number
- ix. Procedures undertaken (including operators),
- x. Smoking status,
- xi. Patient plaque scores
- xii. Additional treatment codes.



#### **4.3.4.2 Summary**

This section has described the case study data extraction process, the data structure and variables obtained. This shows the complex structure behind the user interface. The process of obtaining data related to a particular patient requires a purposeful understanding of how data tables are linked in the schema. Further still, this shows the importance of having clinicians and health services researchers take part in the process of design of schemas or data base tables. This is because at times useful data on patients or the process of care are not appropriately stored within tables or are omitted. The data bases contain a lot of information on actions such as whether logging in and out was undertaken rather than the purposes of logging in or out. Such factors were noted in the system appraisal and data extraction.

### **4.3.5 Data cleaning and validation of case study electronic patient management data**

#### **4.3.5.1 Introduction**

In this section the data cleaning and validation techniques for resultant data are explained. Section 4.3.5.2 provides an overview and rationalisation of techniques considered for cleaning of these electronic patient data. This is followed by a description of the actual processes of data cleaning and evaluation undertaken in Section 4.3.6. The data cleaning issues identified and the solutions employed are then described in Section 4.3.7.

#### **4.3.5.2 Data cleaning**

The use of electronic patient management data for dental research is fairly new, and in order to ensure validity of the extracted data and undertake cleaning of data, it was necessary to use a combination of techniques from studies in health service research and information technology (Maletic and Marcus, 2000, Hall et al., 2008, Kudyakov et al., 2012, Rahm and Hai Do, 2013, Thomas et al., 2014). The information technology strategies (Maletic and Marcus, 2000, Rahm and Hai Do, 2013) aided the framework for the processes, and the health service studies (Hall et al., 2008, Kudyakov et al., 2012, Thomas et al., 2014), facilitated the development of validation processes. First, the data cleaning of raw data extract is explained. These preliminary cleaning processes were undertaken to remove errors that may have resulted from the data extraction processes itself, inputs from the users in the clinic or software storage. The second process of cleaning was a combination of data cleaning and validation as analysis was undertaken to identify outliers and errors in the data. These are processes that ensured that the extracted data are a true reflection of the expected activity and patient data from UPDA. Chapman (2005) defines these processes as a means to determine inaccurate, incomplete, or unreasonable data. He also adds that these processes improve the data (Chapman, 2005).

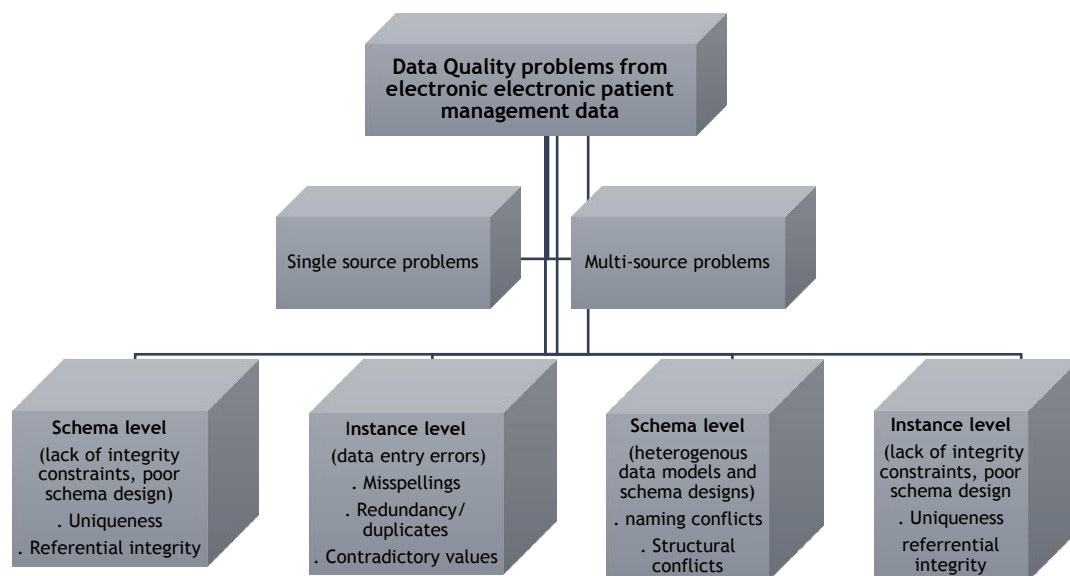
Several data cleaning frameworks are available, and the selection of one depends on the level at which the data cleaning is being conducted, and the type of data bases the data were obtained from. In most cases, data cleaning from electronic management systems is conducted in parallel to data collection, i.e. when the data is being input into the system a repository is set-up to delete and correct entry errors and omissions. This was not possible in this study as the data were historic and the live data warehouse was not accessed during the data extraction phases.

Two data cleaning frameworks were reviewed for use in this study. First was Maletic and Marcus's framework for data cleaning for improved quality (Maletic and Marcus, 2000) and second, the Rahm and Hai Do (2013) strategy. The Maletic and Marcus (2000) framework involved:

- I. Defining and determining error types
- II. Searching and identifying error instances
- III. Correcting the errors (this was modified to omit variables that included errors)
- IV. Documenting error instances and error types
- V. Modifying data entry procedures to reduce future errors ( the Academy was advised on some errors in inputs)

Maletic and Marcus's (2000) data cleaning strategy assumes a prior expectation of errors of a specific kind, and also indicates a need to modify the actual management system, so that future errors are avoided. This was not suitable for this study as modifications to the software were outside the scope of this work.

Rahm and Hai Do (2013) strategy, was the second method of data cleaning considered, and the most suited to this study's design. According to Rahm and Hai Do (2013), data cleaning is detecting and removing errors and inconsistencies from data to improve the quality of data. Their approach was developed for cleaning of data warehouses, which are used for statistics or decision making (Rahm and Hai Do, 2013); thus, providing post-extraction methods of data cleaning, which were required in this study. **Figure 4-4** depicts the classification of data problems according to Rahm and Hai Do (2013) strategy of data cleaning. While cleaning the data these are the errors to be sought.



Source: adapted from Rahm and Hai Do (2013)

**Figure 4-4 Data quality problems: Rahm and Hai Do (2013)**

Rahm and Hai Do (2013) explain that the errors in the data could be at the schema level or at the instance level as presented in **Figure 4-4**. A schema can be described as a “layout” of a database or the blueprint that outlines the way data are organised into tables (Chapple, 2014). Schema-level problems are reflected in the instances; they can be addressed at the schema level by an improved schema design (schema evolution), schema translation and schema integration (Rahm and Hai Do, 2013).

Instance-level problems, on the other hand, refer to errors and inconsistencies in the actual data contents, which are not visible at the schema level (Rahm and Hai Do, 2013). And these are usually the primary focus of data cleaning in post extraction phase; this is how data were input or selected. Both types of errors can be seen in single source data or multiple source data. Single source data are data from one system, which is the case with UPDA data. Multiple source data are from many integrated systems for example when data from many general practices data are housed in one data warehouse. **Figure 4-4** showed the single source and multiple source problems in data quality as described by Rahm and Hai Do (2013). In the case of UPDA’s a number of these quality problems were identified such as; naming conflicts, poor schema design, misspellings and duplicates.

#### **4.3.6 Data analysis for cleaning**

After the identification of quality problems, the data cleaning processes were employed. The process involved data analysis to identify errors and clean data. Data analysis, which is one of the five processes advised by Rahm and Hai Do (2013) for data cleaning, was selected from the other strategies such as back flow cleaning, schema translation, verification and transformation because it did not involve conducting changes to the data warehouse or the actual management system, as with the other strategies. These other processes were outside of the permissions and scope of this study. The data analysis for data cleaning involved frequency analysis identification of errors and solutions. This was all done in the post-extraction phase for both schema and instance level problems. For example to ascertain whether referral period was appropriately populated an analysis of the number of observations with a numerical entry was ascertained. In this particular case less than 20% showed numerical entries this allowed; this variable to be excluded from analysis as part of the cleaning process. Some of the errors ascertained were schema or instance and are outlined in the Sections 4.3.6.1 and 4.3.6.2.

##### **4.3.6.1 Schema level errors**

The schema, which has been described a layout of the database, contained errors evident in the raw extracts that were obtained. As the schema determined the tables, attributes and connections between tables that store data, any errors associated with these elements were identified as schema errors.

###### **4.3.6.1.1 Missing attributes**

Missing attributes are the lack of keys or identifiers for coded data. For example, when attempting to obtain information on smoking status, four codes were available 0, 1, 2 and 3. There were no key/value indicators to inform what each value described. This led to exclusion of this variable from analysis, and the use of another less definitive variable; smoking cessation signposting to give an indication of a patient's smoking status. For other poorly populated or unclear attributes (the value codes for data which had been converted to numerical codes), verification was undertaken using policy documents used for practice at UPDA, and discussions with system operators.

#### 4.3.6.1.2 Lack of integrity

This was a problem of the schema level, and it is associated with an upgrade of the system, which was undertaken when the new PDS plus contract was put in place. The software company added the new relational tables for the new contract onto the old schema instead of designing a whole new schema. This led to long routing in order to obtain the data required

.

#### **4.3.6.2 Instance level errors**

Instance level errors were errors that were at the individual data level, i.e. associated with the data that were input. The following is a list of the errors of this level and how they were managed.

##### **4.3.6.2.1 Data entry errors**

Errors of data entry were the most common type of error in the extracted data. Where several fields were not regularly updated, this led to NULL data when frequency analysis was undertaken. The solution was to omit any variables which were poorly populated, e.g. for example the referral of patients was 20% populated, while all other fields were null. This variable was therefore not included in the analysis.

##### **4.3.6.2.2 Naming conflicts**

Due to upgrades and system changes, at times treatment codes were renamed and old treatment codes were still in the system. This led to naming conflicts. For example 'assessments' could have been renamed to 'care-assessments' following upgrade and if the previous naming had not been excluded from the system, two names for the same procedure could be selected. In order to ensure two codes for the same treatments were not used in the analysis, a higher level descriptor of treatments, referred to as NHS categorisation, was used.

An example of this was as follows. If the treatment undertaken was a Glass Ionomer Cement (GIC) restoration, the naming conflicts could have been that the treatment was coded 'GIC' and also 'gic'. By extracting 'NHS categories' GIC or gic at a higher level would be defined as 'filling'. In this way if GIC was spelled as 'gic' in the period before upgrade and as 'GIC' after upgrade, this higher level variable would pull both of these into one category, which in this instance was named 'filling'.

##### **4.3.6.2.3 Tester patient records/cases**

These were fictitious patients within the system, used to train students on how to operate the electronic patient management system. In the pilot extract, 80 tester records were identified and excluded from the analysis manually. Managers were alerted that these tester cases were present in the system and needed to be deleted. Therefore during the main extraction (phase

two) these tester patients were not present. More details on the variables and the selection process are shown in Appendix 10.6.9

**Figure 4-5** provides a description all the problems encountered and the solutions used in order to obtain robust data for the case study analysis.

DATA QUALITY PROBLEM	• SOLUTIONS EMPLOYED
Naming conflicts, as system was upgraded when UPDA was established and payment contract changed	• Only treatment data that had the same naming structure before and after upgrade were used in the research analysis
Presence of tester patient records which had been used to train users on the system process	• Tester cases were removed from the data extract as they were identified by the dummy patient IDs provided by UPDA system administrators
Systematic duplication errors in found in the main extract and not in the pilot extract	• Observations with systemantic duplication were identified and excluded from all analysis
Missing data/non-populated fields/null fields	• For variables which had between 60-90% non populated fields, these variables were not included in the analysis

**Figure 4-5 identified data quality problems and solutions**



#### **4.3.7 Data validation and verification**

##### **4.3.7.1 Introduction**

Data validation was undertaken to ensure that the data represented actual trends and expected findings; three strategies were employed.

1. Data analysis as already described in the data cleaning Section 4.3.6
2. Manually validation; through comparisons of random patient records with extracted data
3. Comparison with official reports

The second two of the above are considered in turn in this section.

In general health studies diagnostic codes and case-finding algorithms are used to validate data from electronic patient management records (Shiff et al., 2014); however, this is not possible with dental records which do not have diagnostic codes. There are, however other methods such as manual validation that have been employed in other studies (Hall et al., 2008, Thomas et al., 2014). Although mentioned as tedious, they are effective ways of validation and include the following:

##### **4.3.7.2 Manual validation/onsite validation**

Manual data validation/onsite validation was undertaken for the pilot extract and main extract. This method has been used by Hall et al. (2008), to evaluate aggregated data bases from a variety of clinics, and has been shown to provide successful insight into validity of retrospectively extracted data. Thomas et al. (2014) prospectively collected the data manually then compared this to the outputs from the electronic system and found that there was accuracy in the outputs of the electronic data. The process in this research involved scanning for 50 patient IDs from already extracted data. Using the user interface on-site at the clinic, these records were retrieved and actual patient records were obtained at UPDA and checked against the extracted treatment plan data and patient details. The results showed high accuracy of patient details within the patient records. There were, however, duplications of the code 'Assessments'. This implied that for any patient who received an assessment, there was duplication of each assessment in the extracted data. This error was cleaned as discussed in Section 4.3.5.2. The manual validation also checked the 'tester cases' as reported in Section 4.3.6.2.3. It was possible to ascertain that the cases with the name tester in the manual validation records were not actual patients and remove these records.

#### **4.3.7.3 Comparing reports for validation**

Dental providers with the NHS contracts are routinely provided with reports at the end of the year, by the NHS BSA, detailing the claims and associated activity. The reports outline patients seen, ages and payment status. The reports also detail how treatment activity performed in a particular practice compared with the average rate for the country.

These NHS BSA reports were used to validate the data extracted from UPDA's electronic patient management system by comparing patient volume and activity listed in the NHS BSA reports to the data extract results. Similar trends in peaks and troughs between the months were seen in the NHS BSA data comparable to the current study's data extract.

It is, however, important to note that the number of patients as outlined by the NHS BSA data could not match perfectly with the data extracted in this study because patients were counted into the NHS year, which is March-April in the NHS BSA reports, whilst the patient data extracted for the current study assigned patients to academic years (1<sup>st</sup> September – 31<sup>st</sup> August). The patients in the NHS BSA data were counted per visit within the NHS year, while patients in the study data sets were counted once per completed treatment plan in an academic year. These details are covered in Section 4.3.3.5. In the next section the processes of ensuring quality in the case study are demonstrated through the strict validation processes which are described.

#### 4.3.7.4 Ensuring quality of the research design

As the study of UPDA applied case study strategies, relevant issues pertaining to this design were specially examined. These are construct validity, internal validity, external validity and reliability (Yin, 2009).

- a. **Construct validity:** This is the process of identifying the appropriate operational measures for the concept of study. This is closely intertwined with external validity. In this study, the concept proposed is that the undergraduate learning experiences of students training as a team are useful in understanding how different members of the dental team contribute to meeting patient needs. The case study is undertaken in an exploratory manner. The justification for this is the established literature, which highlight gaps in knowledge of data on the patterns of skill mix use, which can be described in this single site. In addition, evidence suggests that undergraduate learning can have a significant impact on future practice, making this site and the team training model, a useful point for research.
- b. **Internal validity:** This is the process where cause and effect are qualified. Although analytical work is undertaken in this study, it is undertaken to establish the existence of relationships between patient characteristics, treatment needs and skill mix; no cause and effect references are made.
- c. **External validity:** This is defining the domain where the study can be generalised. This was an important aspect of this study as the theory development around this undergraduate learning experience, which could be applied to national primary care based on external validity. External validity was therefore established by, first, rigid data cleaning and validation process. Second, pattern matching, which was the comparing of findings from UPDA, with nationally representative data from the ADHS (2009).
- d. **Reliability:** This involves demonstrating repeatability of the methods and outcomes. One of the methods outlined for this is clear protocols (Yin, 1984). An extensive description of the process was outlined in the protocol and this was also presented to ethical committees for approval. Reports were generated as the study went forward to ensure the protocol was maintained. The methods are also described within this thesis.

#### **4.3.8 Other support data sources**

Augmentation of data and additional data were required from other sources, in order to expand the data, to facilitate the operational modelling and to validate the electronic patient management data. The data sets included UK Census data (IMD scores and domains), NHS BSA data (NHS activity) and a supplemental data set obtained from the live records at UPDA.

##### **4.3.8.1 Census data**

Patient post-code data obtained from UPDA was converted to deprivation indices and grid references for analytical study and geographical mapping. The augmentation of the UPDA post-code data to deprivation and grid variables was undertaken using geo-converting tools available on the Office of National Statistics website. The census data obtained through 'Geoconvert' (GeoConvert, 2011) are small area statistics describing the deprivation of an area based on domains and sub-domains of deprivation, which are collective, referred to as the 'Indices of Multiple Deprivation'.

Indices of Multiple Deprivation (IMD) are often used in dental public health research and epidemiology (Maunder et al., 2006, Morris and Landes, 2006, Gallagher et al., 2009, Landes and Jardine, 2010), and in wider health research of disease such as diabetes and epilepsy (Siegel et al., 2014, Steer et al., 2014). There are similar deprivation indices in other countries such as Scottish Indices of Multiple Deprivation (SIMD) (Ralston et al., 2014), New Zealand's Deprivation Index (NZDep)(Salmond and Crampton, 2012) and South African Indices of Multiple deprivation (SAIMD)(Noble et al., 2010).

The English IMD is a weighted combination of seven indicators, namely:

- employment deprivation, 22.5%
- Income deprivation, 22.5%
- health deprivation and disability, 13.5%
- education skills and training deprivation, 13.5%
- barriers to housing and services, 9.3%
- living environment, 9.3%
- crime, 9.3%

(Department for Communities and Local Government, 2011).

IMD was developed as a small area measure of deprivation within Lower Level Super Output Area, (LSOA), which is an area of 1000-1500 households (Department for Communities and Local Government, 2011). There are two supplementary indices; the Income Deprivation Affecting Children Index (IDACI) and the Income Deprivation Affecting Older People Index (IDAOPI) (Department for Communities and Local Government, 2011). The overall IMD is largely interdependent with the sub-domains. **Table 4-2** provides an overview of the seven domains which are weighted and aggregated to form the overall Indices of Multiple Deprivation score.

**Table 4-2 Domains and sub-domains of Indices of Multiple Deprivation**

Domain	Domain description
<b>Income Deprivation</b>	The purpose of this domain is to identify people who are experiencing income deprivation. It is associated with the two supplementary variables. <ul style="list-style-type: none"> <li>Income Deprivation Affecting Children Index (IDACI)</li> <li>Income Deprivation Affecting Older People Index (IDAOPI)</li> </ul>
<b>Employment Deprivation</b>	It comprises 6 indicators and is considered as the involuntary exclusion of the working age population from the labour market. This is based on information from the Department for Work and Pensions.
<b>Health Deprivation and Disability Score</b>	Comprises 4 indicators. It measures rates of poor health, early mortality and disability in an area and covers the entire age range.
<b>Education Skills and Training Deprivation:</b>	This domain is structured into two domains: children/young people and skills. It measures the level of deprivation in relation to skills and educational qualifications in an area.
<b>Barriers to Housing and Services:</b>	This domain is sub-divided into two. Geographical Barriers to services which include distance from the GP, supermarket, post office and primary school. Second sub-domain, is wider barriers which constitutes, house crowding, homelessness ownership of homes etc.
<b>Crime and Disorder:</b>	This domain measures the rate of recorded crime for four major crime types, namely burglary, theft, criminal damage and violence. Thus representing the risk of personal and material victimisation at a small area level.
<b>Living Environment:</b>	This comprises two sub-domains i) Indoor living and ii) outdoor living.

Source: Department for Communities and Local Government (2010)

Before IMD, England had the Townsend measure deprivation index (Townsend, 1979), which was based on census data, meaning it took 10 years to obtain new data. IMD on the other hand is based on routinely administrative data allowing more regular updates (Ralston et al., 2014).

Deprivation indices are known for their use in health research investigating the relationship between negative health and social determinants (Bailey et al., 2003). However, one criticism of IMD is that the regular update bears little significance on the change and researchers who may not obtain the most recent version of the measure should not be too concerned (Ralston et al., 2014). IMD is ever useful in current dental research for England, as clear geographical disparities in oral health are shown in national surveys (Steele and O'Sullivan, 2011, Office of National Statistics, 2004). Clear identification of the predictors of disparities can be possible with the investigation of the IMD as a whole, or more definitively, by separating the domains.

In the past, employment was used as a measure of social class and would give an indication of socio-economic status. This grouped individuals based on their professional backgrounds or the head of household's professional background. This measure was used in the ADHS (2009). Other measures that have been used to indicate deprivation have included income, which is widely used in other countries such as (Larrimore, 2011, Fillenbaum et al., 2013), but this is not regularly collected data in the UK. At present IMD provides the most useful and definitive measure of deprivation.

#### **4.3.8.2 Adult dental health survey data [ADHS] (2009)**

The reports from the ADHS 2009 (Steele and O'Sullivan, 2011), have been pivotal in describing the future needs of the population and have implications for dental policy nationally. In this study, the ADHS (2009) results on reported trends in treatment (Steele and O'Sullivan, 2011, White et al., 2012) are compared with some of the findings from the analytical study of UPDA. The comparison was undertaken to ascertain whether the patterns revealed by the case study match with national findings, providing external validity and exploring the potential for theoretical generalisations that led to the operational modelling exercise.

#### **4.3.8.3 NHS Business Service Authority data**

These are data provided by the NHS BSA. Two forms of NHS BSA data were used in this research. The first were returns provided to UPDA following claims. These are reports provided to all NHS dental contract holders. The second was obtained after a Freedom of Information request was submitted. It detailed all NHS dental activity for practices for which payment claims have been made. These data were used for three purposes.

1. To aid validation of extracted data [section 4.3.7.3]
2. To compare the changes in the volume of treatments activity in a sample of 100 treatment plans for UPDA and England in the year 2011/12 (first year of team training).
3. For use in the operational modelling exercise to represent the demand in England in the NHS year 2011/12 (NHS Business Service Authority, 2013).

In the past the Dental Practice Board held the NHS data. Studies have used the DPB data in modelling of workforce requirements (Kleinman et al., 2009, Gallagher et al., 2010, Harper et al., 2013). The details of the request made are in Appendix 10.6.10.

#### **4.3.8.4 Supplemental data from live patient management system at UPDA**

Following statistical advice, a random convenience sample of 100 cases was obtained manually to provide details of delegation of two treatments; scale and polish and fluoride varnish. This was because these two treatments were not coded to a provider in the main data extract, and were important for the complete analysis of skill mix. There was a need to have a clear prescription to DCPs and this was only available in a few records as some opted for unclear free text. The process undergone to obtain the 100 supplemental data involved scrutinising over 300 cases in order to obtain clear records where treatment was complete. The records were obtained from academic year 2011/12.

#### **4.3.9 Ethical approval and data handling**

Ethical Approval for the research was requested and obtained from NHS REC Fulham and NHS and R and D approval from Southampton (See Appendices 10.6.11 and 10.6.12).

An information poster was placed at the clinic to inform patients of the study and extra information leaflet were available for patients who wanted more information. This is in line with the best practice guidelines (Wellcome trust, 2009). (See Appendices 10.6.13. and 10.6.14) The data management complied with the Data Protection Act 1998 (Legislation.gov.UK, 1998).

Ethical issues carefully considered involved the handling of all the data containing patient details; these were anonymised and assigned unique identifiers. Identifiable data such as post-codes and dates of birth were erased after they had been converted to geographies and age.

Data were kept on password protected databases that were further secured on a password protected computer and backed up on an encrypted USB device in a locked room at Kings College Dental Institute Denmark Hill Campus and the Biostatistics and Research Methods Department of Kings College London Dental Institute.



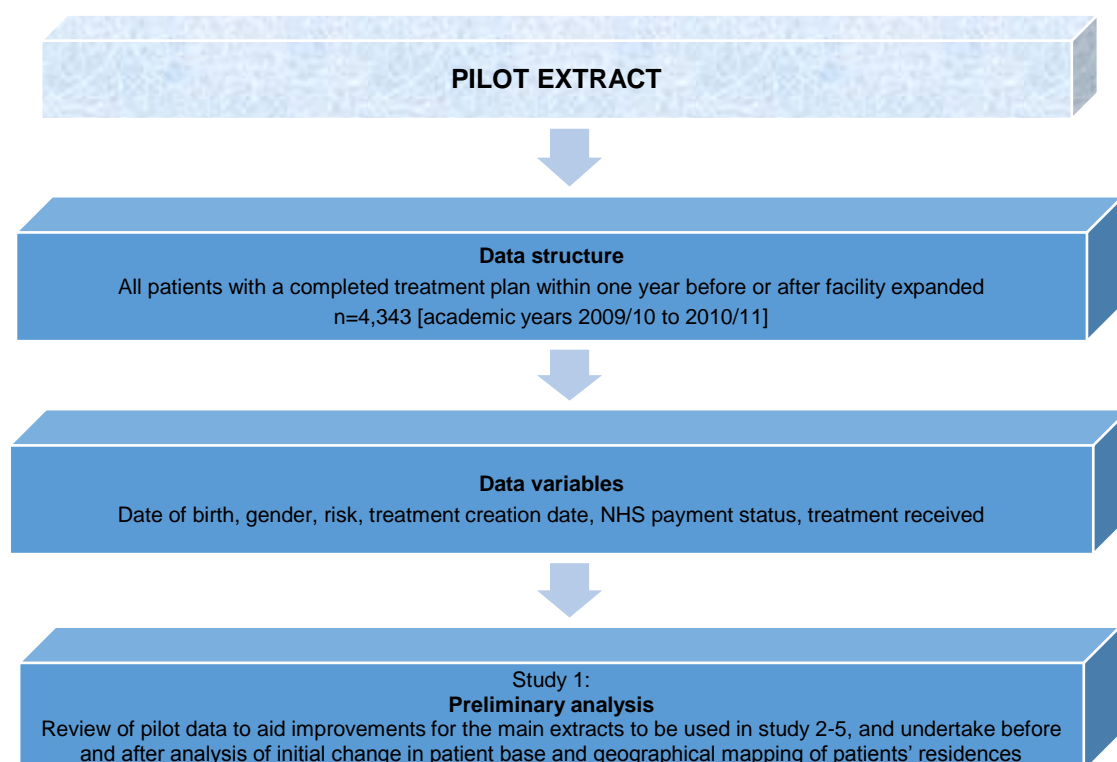
## 4.4 Study data sets and electronic data analysis

### 4.4.1 Introduction

The research data sets were generated from the pilot data extract [academic years 2009/10 and 2010/11], and the four-year main data extract [academic years 2008/09 to 2011/12], and structured to meet the research objectives. This section describes the process undertaken to create data sets which were used to undertake the first four statistical studies of this research. This is followed by a step by step description of each of the studies in sequence.

### 4.4.2 Pilot data extract

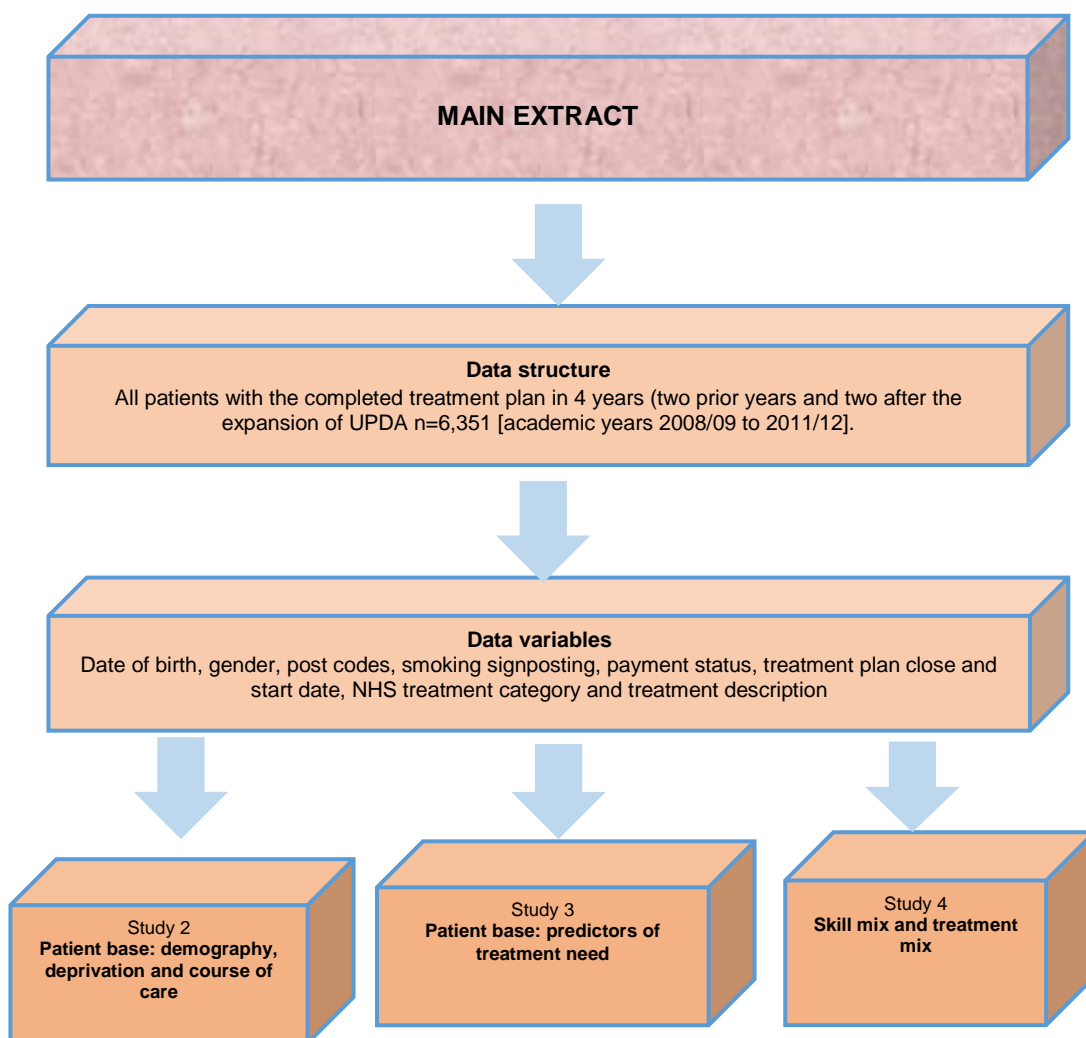
The pilot data extract consisted of data from one year before and after the expansion into UPDA [2009/10 and 2010/11]. These data were used to obtain a more robust main extract and to compare the changes in patient base and treatment in the initial first academic year (2010/11) of expansion of the facility and the year before expansion (2009/10). This analysis was used to fulfil part of *Objective 1*. See Section 3.2. **Figure 4-6** below gives details of the nature of the data set derived from the pilot extract and the studies that were designed from these data.



**Figure 4-6 Pilot data extract, structure and studies conducted**

#### 4.4.3 Main data extract

The main data extract produced four-year data sets. The data sets were used to analyse the trend in treatment activity, relationship between treatment and patient characteristics and to establish the skill mix patterns of practice at UPDA. These analyses fulfilled aspects of *Objectives 1, 2, 3, and 4* of this research as outlined in Section 3.2. **Figure 4-7** below is a diagram of the data sets and studies derived from the main extract. Details of the study methods are in the next Sections 4.4.6 to 4.4.8.



**Figure 4-7 Description of main data extract, structure, variables and resultant studies**

#### **4.4.4 Study sections described**

Each study was developed in order to address an accompanying research objectives. This section describes each study in detail, highlighting questions asked of each data set and statistical techniques where relevant.

#### **4.4.5 Study 1] Pilot study: preliminary analysis**

The pilot data were used for two purposes: first to refine the content for the main data extract and second, to address part of Objective 1.

*Objective 1: To describe the patient population accessing a primary dental care training establishment in terms of demography, deprivation and geographic area of residence before, and after, the start of team training and the expansion of services.*

In order to describe the change in the patient base, an analysis was undertaken to compare patients in the two years surrounding the expansion into UPDA as outlined below:

- i. Analysis of the initial changes in the facility's patient demographic characteristics in 12 months prior to and after expansion of the facility
- ii. Analyses and mapping of geographical differences in residences and deprivation status of patients in the initial period of UPDA's expansion compared to the period prior
- iii. Multivariate modelling of the influence of geographical deprivation of patients' residences to attendance before or after UPDA was expanded

##### **4.4.5.1 Before and after analysis: changes in patient base**

A selection criteria was used to establish patients who would be subject to the before and after analysis. This was any patient with a closed/completed treatment plan in the 12-month period prior or within the 12 months following dental service expansion (n= 4,343). First, descriptive and univariate analyses were undertaken, evaluating the volume and group differences in the proportion of patients within the following socio-demographic variable groups:

- Patient age
- Sex
- Payment status

- Deprivation status
- Treatment activity

To analyse group differences for the categorical variables such as sex, ethnicity, payment status and treatment activity, frequency analysis was undertaken, and for continuous variables such as Indices of Multiple Deprivation (IMD) score and age, mean or median and standard deviation were compared between patients from the period prior and the period after UPDA was expanded. Univariate analysis was undertaken using chi-square tests for categorical variables and t-tests for continuous variables to examine whether differences observed between the two groups under comparison were statistically significant (Armitage et al., 2008).

#### **4.4.5.2 Before and after analysis: geographical mapping**

The second part of the before and after analysis involved geographical mapping of patients who attended UPDA before and after expansion. This provided an abstract representation of areas from which patients accessed UPDA in the two periods. Geographical information systems (GIS) for mapping are known to be useful tools for the analysis of potential users residences and service availability (Susi and Mascarenhas, 2002). A number of studies on dental service utilisation have used GIS to map patients' areas of residence and ascertain the geographical distances from which populations were accessing dental services, for purposes of ascertaining whether this was a barrier (McCormick et al., 2008, Kruger et al., 2012, Kruger et al., 2013).

In this study, Quantum GIS software was used in the geographical mapping. It is a type of software that maps, stores, retrieves and manipulates spatially referenced data (Malczewski, 1999). Other types of software used include Map Info (Map info, 2012) and Arc GIS (Arc GIS, 2012) and all contain similar aspects and may vary in user interfaces. Quantum GIS was selected because it was compatible with the maps for use in this study from the Ordnance Survey, which is the official mapping agency for Britain (Ordnance Survey, 2012). These were made available through EDINA, an online service that provides researchers and academics in the UK with digital maps and other online materials (EDINA, 2013). The data were displayed according to boundary wards in Portsmouth and the surrounding county.

Geographical mapping of data in this study provided a visual picture of where patients who accessed UPDA came from, before and after expansion. In this study it was useful in

investigating whether groups from deprived wards with poor dental access rates, (NHS Dental Public Health Team, 2011) were accessing UPDA.

To display the residence on the GIS maps, patients' post code data was converted into spatial references (eastings and northings) using the ONS tool Geoconvert (GeoConvert, 2011). The eastings and northings were uploaded in CSV format on to Quantum GIS and were overlaid on boundary maps in the form of layers and vectors. Patients were represented by either brown or green dots and overlaid on their area of residence in the maps to provide visual representation of the geographic spread of local residents.

#### **4.4.5.3 Before and after analysis: multivariate analysis**

The final part of the before and after analysis explored whether there were statistically significant differences in the geography of patients, in reference to their geographical deprivation from services. This was undertaken using a logistic regression model. The model tested the likelihood of utilising the dental practice after extension, predicted by socio-demographic factors: age, sex, gender, payment exemption and geographical deprivation scores, which were obtained by converting post codes to geographical barriers to services (GBS) score. Geographical deprivation score is a sub-category in the overall IMD. The results of this first study are presented in chapter five and a published article in the Appendix 10.6.23.

#### **4.4.6 Study 2] Patient base: demography, deprivation and course of care**

Study two was the first of the studies undertaken on the main data [covering the academic years 2008/09 to 2011/12]. This study explored the patient base and courses of care as described by the completed/closed treatment plans in the four-year study period. Age groups, deprivation, sex, payment status and smoking behaviour were included in the analysis as descriptors of patient characteristics. This study further addressed Objective 1 of this research:

- 1) *Objective 1: To describe the patient population accessing a primary dental care training establishment in terms of demography, deprivation and geographic area of residence before, and after, the start of team training and the expansion of services*

The study process can be described as involving:

- i. Exploring volume of treatment plans in the academic years 2008/09 to 2011/12
- ii. Exploring socio-demography of patients who received the completed treatment plans in the main data set [covering the academic years 2008/09 to 2011/12]
- iii. Examining re-attendance patterns of patients.

Note: The term 'treatment plans' is used for the plan of the course of care provided. For some patients this will have been the full plan of treatment, and for others, treatment plans will have closed because the patient did not return for care. The treatment plans therefore represent all the treatment provided within that course of care.

##### **4.4.6.1 Exploring volume of completed treatment plans**

First, all completed/closed treatment plans within the study period were analysed for the volume by months. Specifically, how many of the total 10,371 treatment plans completed in the study period were started or completed in different months. As the data were cross-sectional, analysis of treatment volume by academic years was managed by creating two data sets and asking the two following questions:

**Q: How many treatment plans were started within each month?**

**Q: How many treatment plans were completed within each month?**

The first data set, which analysed the volume of new treatment plans started by month and academic year, was derived from a variable within the main extract named 'treatment plan start date'. The second data set, which analysed the volume of treatment plans completed, by month and academic year, was derived from a variable named 'treatment plan completion/ close date'.

#### **4.4.6.2 Exploring socio-demography of patients**

Using the same main study data extract [covering the academic years 2008/09 to 2011/12], the trend in socio-demography of patients, by the number of treatment plans across the four-years was analysed. For this analysis the following question was asked of the data.

**Q: What is the proportion of patients, defined by their socio-demographic characteristics, who received completed treatment plans, by the year in which the treatment plans were completed?**

The patients' socio-demography was counted as many times as they had received a new treatment plan in one academic year. The socio-demographic variables included in this investigation were age, ethnicity, sex, payment exemption status, quintiles of deprivation and smoking status (inferred from the variable that ascertained whether a patient had been signposted for smoking cessation or not). The variable quintiles of deprivation were obtained from the conversion of lower super output area [LSOA] to quintile of deprivation in the PCT of Portsmouth. This was undertaken using spreadsheet data from the Department for Communities and Local Government (Department for Communities and Local Government, 2011). Details in Section 4.3.8.1

#### **4.4.6.3 Re-attendance patterns of patients**

The analysis of re-attendance was undertaken by creating 4 data sets for each academic year, based on the date of completion of a plan. Within each data set de-duplication of patient ID was done, allowing a patient to only appear once per year. After this, the four data sets were re-merged and using aggregate function in SPSS a variable was obtained from a count of the number of times a patient ID was seen and a frequency analysis of the aggregated variable was undertaken.

#### **4.4.7 Study 3] Patient Base: predictors of treatment need**

This study was undertaken to address Objective 2.

*Objective 2: To investigate the relationship between patient socio-demography and treatment received during courses of care and over time.*

This study analysed treatment activity and the relationship between treatment needs and patient characteristics. The study process can be described as involving the following:

- i. Investigating expressed treatment needs by treatment type e.g. restoration, tooth extraction etc.
- ii. Analysing expressed treatment needs and patient socio-demography
- iii. Univariate analyses of expressed treatment need by socio-demography
- iv. Multivariate analysis of predictors of expressed treatment needs
- v. Multilevel logistic regression modelling of area level predictors of expressed treatment needs.

##### **4.4.7.1 Investigating expressed treatment needs by treatment type**

Frequency analysis was undertaken on the observations of items of treatment within treatment plans in the main data set, and the most frequently occurring treatments were ranked from highest frequency to lowest frequency. Any treatments associated with duplication errors were excluded from the analysis. This means four treatments out of the 69 NHS treatment categories were excluded. Details of this data cleaning action were discussed in Section 4.3.6.

##### **4.4.7.2 Analysing expressed treatment needs and patient socio-demography**

This was undertaken to ascertain the nature of expressed need/demand for dental treatments by patient socio-demography. This part of the study focussed on the most commonly occurring treatments for each patient captured in the data set. This involved nine treatments which had the highest volume of observations namely:

- Instruction/advice
- Scale/ Polish
- Fissure sealants



- Periodontology: non-surgical
- Tooth restorations
- Endodontics
- Tooth extractions
- Partial dentures
- Crowns

Nine separate data sets were developed from the main data extract for each treatment. Each contained the unique 6,351 patients and a binary variable, The binary variable in each data set gave information on whether or not a patient had received one of the procedures at least once in the four-year period marked as '0' for 'never' and '1' for 'yes at least once'. To create the binary variable a series of sequential, sorting and filter strategies in SPSS 20 statistical software was conducted on the main data set. This variable facilitated the description of the proportion of patients who had received these treatments; providing a type of point prevalence of treatment. The question asked of the data was:

**Q: What is the proportion of patients who had received each of these procedures at least once?**

#### **4.4.7.3 Univariate analyses of expressed treatment need by socio-demography**

The nine treatments were further analysed for statistical associations with patients' individual characteristics (demography) and contextual characteristics (area of residence). Nine data sets each of the same 6,351 patients with a unique binary variable of treatment experience underwent univariate analysis. The question asked of the data set was:

**Q: What is the proportion of the 6,351 patients, within each socio-demographic group, who had received each of these procedures at least once?**

Independent sample t-test and chi-square test were conducted to ascertain any statistically significant differences in the proportion of patients who received a particular procedure by socio-demography e.g. age, sex, deprivation etc. There were a few missing data in some of the socio-demographic variables. These variables were smoking and quintiles of deprivation. The quintiles of deprivation were generated from post codes, therefore where the post codes were not valid, augmentation was not possible. Smoking status variable was only available in the post

team training years and was thus the reason for the missing data in cases who had not attended during post expansion; details explained in Section 4.3.4.1.

#### **4.4.7.4 Multivariate analysis of predictors of expressed treatment needs**

Logistic regression models were undertaken on treatments which had more than two socio-demographic variables showing statistically significant associations with the binary treatment variable (treatment procedure) in the univariate analysis. These were five out of the nine treatments;

- Instruction/advice
- Tooth extractions,
- Scale and polish,
- Partial denture treatments
- Tooth restorations

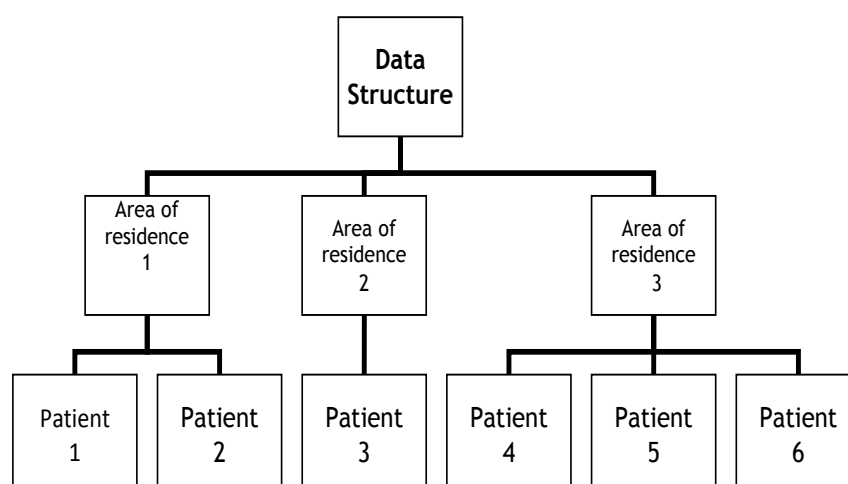
All the multivariate analysis models were limited to adult patients, due to the inclusion of the predictor variable - adult payment exemption status - which was found to have associations with most treatments in the univariate analysis. In contrast, the majority of children's care is exempt from charges (NHS Choices, 2014)

The multivariate analysis was also limited to patients who had been seen at least once in the period post-UPDA expansion in order to give a global picture of expressed treatment need. The inclusion of the smoking cessation variable, which was only populated in records of patients who had been seen in the period after UPDA expanded, ensured this. The models were tested for prediction accuracy using Random Operator Curves (ROC) which gives an indication of diagnostic strength of a model (Zou et al., 2007).

#### 4.4.7.5 Multilevel logistic regression modelling of area level predictors of expressed treatment needs

Multilevel modelling was undertaken to ascertain the influence of area of residence on treatment need. Area of residence was described by LSOA. See Section 4.3.8.1. This statistical technique exposes the influences of grouping characteristics on data (Leyland and Groenewegen, 2003). The grouping characteristics can be neighbourhoods, schools, institutions etc. (Brunton-Smith, 2013). In this research LSOAs was selected as the grouping variable as this was the smallest aggregating variable available augmented to the data set. Multilevel analysis (MLA) extends a normal regression analysis to a situation where data are hierarchical (Leyland and Groenewegen, 2003). The use of MLA in public health research embraces the concept of local area influences on health outcomes. And as researchers are moving towards ensuring that findings from there work are transferrable into actual public practice and policy (Glasgow and Emmons, 2007), MLA can help identify more concisely the sections of the population which may require interventions more than others. This is because with MLA patient outcomes are considered as a function of both the individual and the areas they come from, and thus ensuring better understanding of the population (Brunton-Smith, 2013).

The feasibility of conducting MLA is based on the nature of data grouping. The structure of a multilevel group can include two or more levels. **Figure 4-8** shows a simple multilevel data structure.



**Figure 4-8 Example of two-level grouped data structure**

The relationships could be more complex such as cross-classified, multiple membership, spatial or combinations (Brunton-Smith, 2013), where for example level one member could belong to more than one level or even two groups. The data available from UPDA were patient and treatment plan level, nested within postcode of residence, which were converted into other geographies such as LSOA, through geoconvert tool as mentioned before (GeoConvert, 2011).

MLA was restricted to adult patients attending from the Portsmouth wards, in order to obtain a reasonable number of patients per LSOA. The number of LSOAs was 123 and number of patients was 2,062 and limited to the two-year post expansion period similarly to the multivariate analysis. Only two treatments were investigated for area level influences; these are tooth extractions and scaling/polishing. This was due to findings from multivariate analysis Section 4.4.7.4 that suggested a relationship between the prevalence of these procedures and an area level measure; Quintile of Deprivation in PCT.

#### **4.4.8 Study 4] Skill mix and treatment mix analysis**

Overall, Study 4 was developed to address Objective 3.

*Objective 3. To examine the skill mix practice at UPDA in relation to patient socio-demography and treatments provided during team training*

The statistical analysis applied to this objective was designed to aid:

- i. Characterisation of delegation of patients
- ii. Description of delegation of tasks
- iii. Univariate analysis of individual 'skill mix coded treatments' and delegation

The study was undertaken on two data sets. The first data set was derived from the main study data, but limited to the first two years of team training; academic years 2010/11 and 2011/12 described in Section 4.3.4.1. The second data set was the supplemental data set obtained from the live patient management system used to describe delegation of treatments which had not been coded for skill mix as explained in Section 4.3.8.4.

##### **4.4.8.1 Characterisation of delegation of patients**

To describe the nature of delegation of patients between dental students and DCPs analysis was undertaken on a part of the main four-year data set. This included items of care, and procedures codes that indicated the performer of the treatment (dental student or dental hygiene-therapy student). For example, an amalgam restoration would be coded either amalgam restoration for dental student [Amalgam D]S] or amalgam restoration for dental hygiene-therapy student [Amalgam HTS], depending on the provider of care. All patients who had one or more skill mix coded procedures were eligible for analysis (n=2,063). The 'skill mix coded procedures' were descriptively analysed as part of this study. These included paediatric tooth extractions (these could include teeth extracted during normal shedding of primary teeth in children); restorations; pulpotomies (endodontic treatment on paediatric teeth); fissure sealants and urgent care.

To establish if there was a significant difference in delegation by patient characteristics, independent sample t-tests and chi-square tests were undertaken on the delegation variable and socio-demographic characteristics. A logistic regression model was then used to ascertain

whether any socio-demographic variables could predict delegation while controlling for the effects of all other variables.

#### **4.4.8.2 Description of delegation of tasks**

Also used in the analysis of task delegation was a supplemental data set (n=100) outlined in Section 4.3.8.4, which was obtained manually from user interfaces of patient records. The supplemental data set was used to examine the delegation practice of two preventive treatments; scaling/polishing and fluoride varnish, as these had not been coded for delegation/skill mix in the main data extract. This supplemental data provided an estimate of the proportion of cases for each of these treatments.

From the main extract, delegation of urgent mucosal conditions, tooth extractions, pulpotomies, fissure sealants and tooth restorations were analysed. This was followed by an analysis of delegation of each treatment by age group and this was to be used in the operational modelling exercise.

#### **4.4.8.3 Univariate analysis of individual ‘skill mix coded treatments’ and delegation**

Two treatments were selected for a univariate analysis of the relationship between socio-demographic status and delegation of treatment: 1] tooth restorations 2] fluoride varnish. These two treatments had a convenient sample of patients who had received this care. This analysis involved investigating whether age group, exemption from NHS payment status, smoking status and quintile of deprivation were likely predictors of delegation for patients who had received these treatments at least once in the two years of team training.

## 4.5 Operational research modelling: deterministic model

### 4.5.1 Introduction

The second part of the project is the operational research exercise. This section provides the rationale for the exercise, which modelled alternative skill mix scenarios for primary dental care based on findings from UPDA data analysis, policy on scope of practice and evidence based practice. Section 4.6.1 debates the principles and approaches for the use of operational research in the field of health. Section 4.6.2 provides an overview of the use of operational research in dentistry. Sections 4.6.3 describes the model strategy used in this research and alternative approaches that could have been undertaken instead. Section 4.6.4 explains the process of data validation employed. Details on the operational research study stages follow in Section 4.6.5 .

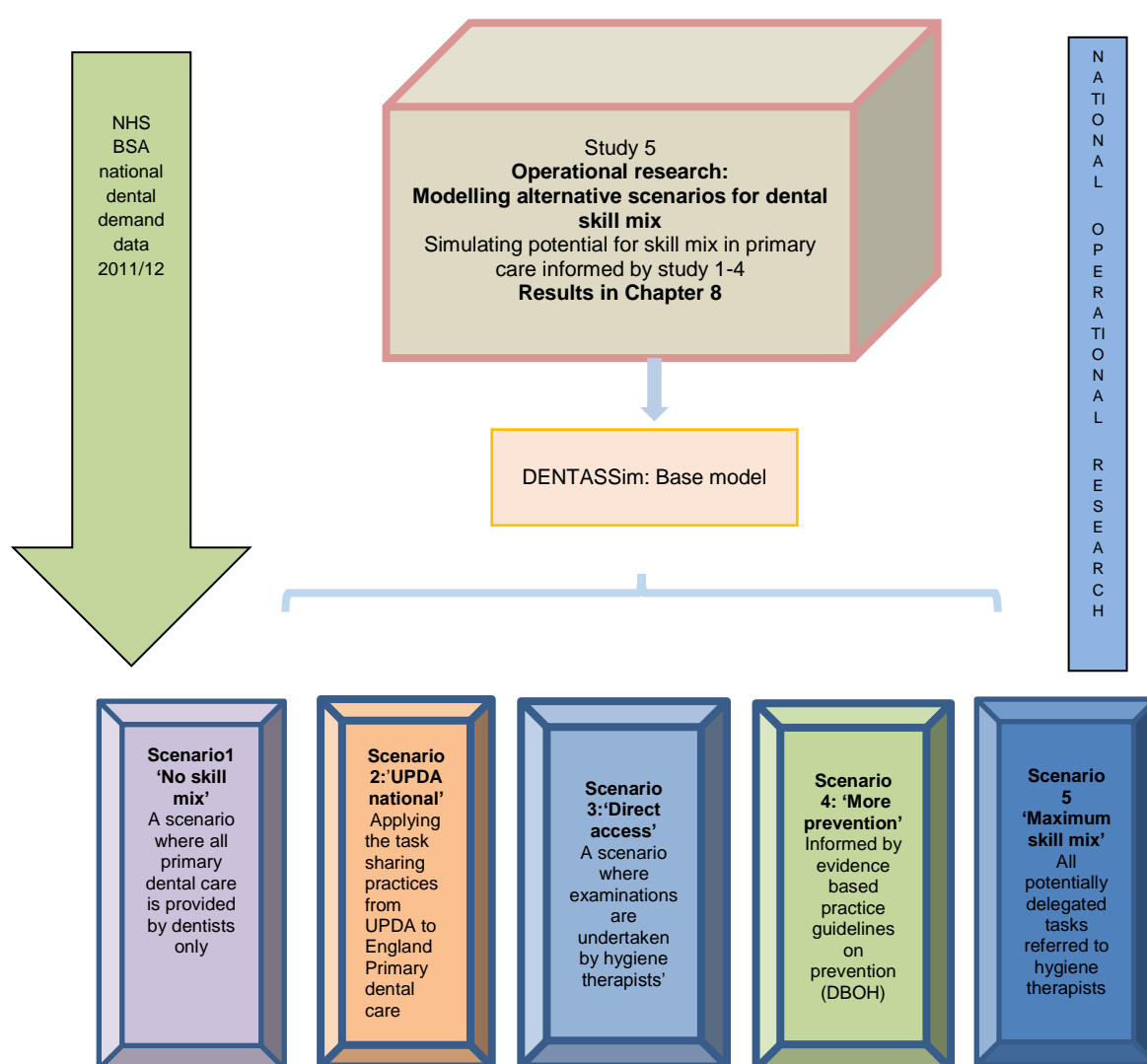


Figure 4-9 Overview of the operational research scenarios

## **4.6 Overview of the operational research exercise**

The operational research exercise involved the construction of a supply and demand model that simulated the learning from the study of UPDA data into an abstract model representation of primary dental care practice in England. This model determined the skill mix required depending on a number of alternative scenarios. The model involved four stages and included data from the National Health Service Business Service Authority (NHS BSA), which reported on dental treatment for the whole of England in one NHS year (2011/12). The alternative scenarios were simulated on the model based on scope of practice policy regulation and improving preventative evidence-based practice. Scenario outputs were clinical hours, whole time equivalents (WTE) and salary costs, which were based on the mentioned specific national expressed treatment volume.

### **4.6.1 Principles of operational modelling approaches**

Operational research (OR) modelling in health research has been a vastly growing field within the last four decades. This research finds its roots in the field of defence in England during World War II, as it was used to study ways of improving the operational efficiency of communication systems (Rajgopal, 2004, Royston, 2009). 'Operational research helps to identify solutions to problems that limit quality, efficiency and effectiveness, or to determine which alternative service delivery strategy would yield the best outcome' (World Health Organization and Global Fund, 2009). By 1979, 188 articles had been frequently cited exploring the use of operational modelling in health research (Fries, 1976). Currently operational research in health is widely published with systematic reviews indicating the breadth of the subject (Brailsford et al., 2009, Royston, 2009). The processes of operational research are described differently depending on the field of study but mainly constitute a problem stage, model development and simulation of the model. An example from World Health Organization and Global fund (2009) operations research programmes suggests the following **Figure 4-10**

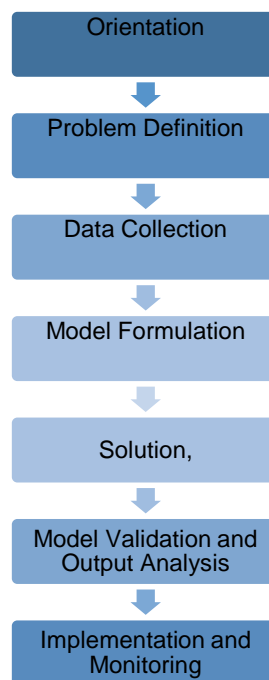




Source : (World Health Organization and Global Fund, 2009).

**Figure 4-10 WHO and Global Fund Operational Research Programs Guideline**

Rajgopal (2004), although using an engineering approach describes a different set of areas but bearing similar stages as shown below in Figure 4-11.



Source: Rajgopal (2004) Principles and Approaches to Operations research

**Figure 4-11 Operations research approach Rajgopal (2004)**

Both the World Health Organization and Global Fund (2009) and Rajgopal (2004) show a sequential process of design with similar stages involving thoughtful development, simulation and evaluation of the model.

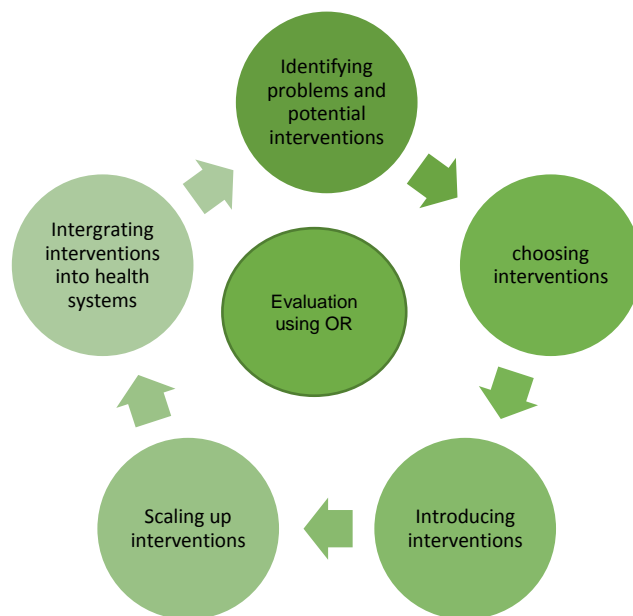
#### 4.6.1.1 Selecting a modelling approach

The strategy selection (World Health Organization and Global Fund, 2009) or the model formulation (Rajgopal, 2004) is a significant part of the OR process. This stage dictates the outputs of the model. In establishing the approach to undertake, there are some principles that have been proposed. Primarily, it is important to keep in mind that there is no ideal model (Bretthorst, 1996). Therefore, when identifying the approach a balance between various significant elements of the model needs to be examined. First to consider is that the model should be a selective abstraction of reality, and therefore the model should attempt to include as close a depiction of the system being modelled as possible (Rajgopal, 2004). This process involves developing an accurate abstract while maintaining simplicity of the model (Bretthorst, 1996, Rajgopal, 2004). Rajgopal (2004) describes this as a balance between ensuring that the model is representative of the actual system and tractable, because it ensures that the model is accurate but also can be replicated as associations are clear within the model. The nature of data available also plays a role in model selection, as the less assumptions the better (Harper et al., 2013). In considering all these it is important to ensure that parameters instituted in the model can be populated with available data (Rajgopal, 2004). Finally the type of technique to use in the model is important, whether there is theory modelling or factual modelling. There are four types of models categories namely

- **Physical Models**, which are scaled down versions of the original. Examples include a globe
- **Analogic Models**, which are physical models as well but use analogue to describe the system
- **Computer Simulation Models**, where one inputs the abstract into a computer and using software languages, complex relationships can be developed and simulated
- **Mathematical Models**, where one captures the characteristics of a system or process through a set of mathematical relationships. This has been employed in this study.

#### 4.6.1.2 Uses of operational research models

As explained in Section 4.6.1 operational research or OR has its foundation in the military during the Second World War (Rajgopal, 2004, Royston, 2009). In the years that followed the war, it became clear that OR techniques could be used for long-term strategic planning and resource allocation (Rajgopal, 2004). OR is used in research in economics (Rand and Eglese, 2014), engineering (Rajgopal, 2004) and health (Harper, 2002, Harper and Gamlin, 2003, Royston, 2009, Brailsford and Vissers, 2011, Gallagher et al., 2013). The future for OR is said to be related to the growing sophistication of the tools used and Royston (2011) has developed some of the expected uses for OR in health care in the years to come as shown in **Figure 4-12**.



Source Royston (2011) Meeting global health challenges through operational research and management science

**Figure 4-12 Global health challenges for operational research and management science**

According to Royston (2011), OR has the potential to contribute to tackling several global health problems. He, however, suggested that this will require changes that involve advances in research and analysis of organization and delivery of health care, so as to provide better understanding of the context for OR to be undertaken. This approach is already being shown, as recently the CDC has published OR strategies that use local data in order to ascertain resource allocation and even vaccination programmes (Zaric, 2013).

#### **4.6.2 The use of operational research for skill mix research in primary dental care**

OR techniques are useful in applying simulations based on scenarios for futures research in health (Gallagher, 2002, Garrett, 1999). This is why this technique is particularly helpful in planning for workforce numbers in general health and dentistry, where aspects of a system such as number of personnel joining and leaving the system are expected to change in a period of time, or population growth is expected. This could include a futures model which can simulate the likely situations to come.

OR has been used in various countries trying to plan for their future dental workforce, and examples include the Netherlands (Burgersdijk et al., 1994) Sri Lanka (De Silva, 2012) and Lebanon (Doughan et al., 2005). An example is Burgersdijk et al. (1994) who modelled dental workforce requirements for the Netherlands, using five sub-models/stages to describe supply and demand for services. They included predictors of demand such as population, pathology, dental attendance and treatment needs. The result was that they were able to test a range of scenarios substituting the activities from dentists to hygienist. OR in this present research similarly considers predictors of demand and skill mix use.

More recently in England operational research models using future scenarios were used to explore the required skill mix of the dental team to meet future need and demand of older people in England to 2028 (Gallagher et al., 2010, Harper et al., 2013), and to estimate cost-effective dental skill mix for South Central Region (Gallagher et al., 2013). The national modelling work on dental skill mix use for older people in England by Gallagher et al. (2010) applied a three-stage computer model to consider expressed treatment need (demand) for dental care for older populations, workforce supply and skill mix. Monte Carlo simulation was used to give an indication of the uncertainty surrounding this projected demand. Various future scenarios that employed skill mix were tested on the model, informed by population projections and their implications for the oral health of older people (Kleinman, 2006, Kleinman et al., 2009). Working time equivalents (WTEs) were analysed, and the treatment demand for older people was based on activity data from the DPB (Dental Practice Board). This was finally analysed descriptively to ascertain the proportion of each treatment service required by older patients in England. The results of this type of scenario work could vary from workforce volumes, ratios,

proportion differences or even cost-ratios for different personnel. This flexibility allows a wide range of use for the results from this type of research (Gallagher et al., 2010).

OR models have been used to make substantial national dental workforce policy decisions in the UK. In 2004, the health workforce review exercise used a supply and demand model that forecast a 10% shortfall of dentists in the future (Department of Health, 2004a). As a result, dental student intake was increased and dentists from abroad were recruited (Secretary of State for Health, 2004). In Scotland the biennial dental workforce review has used operational research modelling to establish the best workforce constitution in Scotland by consistent updates of the model data and parameters (NHS Education Scotland and Information Services Division, 2004, NHS Scotland, 2006, Scottish Government, 2010, NHS Education for Scotland, 2014). In England, the Centre for Workforce Intelligence (CfWI), who have been commissioned by the Department of Health, as well as Health Education England and Public Health England, to look at specific workforce groups and pathways, and to provide materials, tools and resources to inform workforce planning policy decisions at a national and local level, are using operational research modelling techniques to establish the intake of dental students and the potential for DCPs to meet the future demand (Centre for Workforce Intelligence, 2012, Centre for Workforce Intelligence, 2013, Centre for Workforce Intelligence, 2014b).

### **4.6.3 OR model in this research and alternative methodologies**

#### **4.6.3.1 Introduction**

The model developed in this current research used a minimal number of assumptions in order to mitigate the commonly mentioned drawback of operational research, which is several assumptions (Harper et al., 2013). It was a supply and demand deterministic model. As described in Section 4.5.1. The next section describes the deterministic supply and demand model in greater detail as applied to this research and limitations and benefits to their use.

#### **4.6.3.2 A deterministic operational research model**

A deterministic supply and demand operational model was developed for use in this study. The central problem considered for the model was ‘the use of skill mix in primary dental care’, and the analysis of UPDA data was part of the diagnostic process that allowed the construction of theory around the interaction of patient characteristics and treatment needs and use of skill mix. A strategy was then selected of operational research engaging in features of supply and demand (defined by expressed treatment needs), with emphasis on social predictors, as these are highlighted as important factors in literature. A mathematical model which related these aspects of demand together was constructed. These aspects, in addition to validated BDA Heathrow treatment timings (Bearne and Kravitz, 2000), explained in detail in Section 4.6.5.2, represented ‘predictors of dental treatment demand’ in the model. The output ‘supply’ was clinical hours, whole time equivalents, and where appropriate estimated salary costs.

The decision to use a supply and demand model based on the overwhelming understanding that the demand on services is changing due to demographic shifts and technology and the supply of the health workforce should consequently be shaped according to this shift (Morgan et al., 1994, Sibbald et al., 2004, Thompson, 2004, FDI Dental Practice Committee, 2005, Dräger et al., 2006, Kleinman, 2006, Gallagher et al., 2010, Buchan and Campbell, 2013, Centre for Workforce Intelligence, 2013, Gallagher et al., 2013). The potential for supply and demand models to encompass a variety of determinants of expressed needs is shown in the Dutch dental workforce study (Burgersdijk et al., 1994), Scotland workforce modelling (NHS Education Scotland and Information Services Division, 2004, NHS Scotland, 2006, NHS Education for Scotland, 2014), skill mix modelling in England for the older population (Gallagher et al., 2010)

and South Central Region (Harper et al., 2013, Gallagher et al., 2013). In all these studies, the researchers included several factors associated with demand. The current model similarly employs a multistage demand model. The aspect that differs in the current model is that futures approach is not instituted. This is because the primary purpose was to reveal the potential role of the whole dental team to meet demand with an understanding of contemporary needs, which would include prevention and re-organisation of working arrangements. This is different from applying population shifts, which would be required in a futures model and is not the primary focus of this work. This work attempts to provide detailed information on the actual tasks involved as these play a role in quality of care and time taken for practice; factors which significantly influence the skill mix model that can be used.

The supply and demand modelling in this research advances further than just outlining numbers of personnel required for certain demand, but describes personnel by cadre of profession (dentists and dental hygiene-therapists) required to meet demand specific to treatment types and patient groups, which relates to meeting needs. This is in line with literature and research that encourages the planning of human resources for health care while accounting for specific care needs and skills (Swedberg, 1995, Dreesch et al., 2005). Finally, the experimentation involved simulating the model and various other scenarios built to represent relevant contemporary alternative practices within primary care. In the following two sections, alternative modelling techniques that could have been employed are explained.

#### **4.6.3.3 Stochastic operational model**

The current study's model was a deterministic, meaning that the figures within it were fixed. A stochastic model could have been used if there were numbers in the model with a range of uncertainties. In the stochastic approach, the inputs sheet in the demand worksheet would allow alteration of any of the stochastic parameters by changing the deviation from the average value expressed as a percentage change (Harper et al., 2013). This would provide a range of outputs (results) as opposed to fixed figures; giving room for uncertainty.

On the down side, more data are required in stochastic models and that is not always reliably available. These include variance estimates; and if the felt variance is small and just average longer-term values are desired, it would not warrant extra complexity/time to build a stochastic

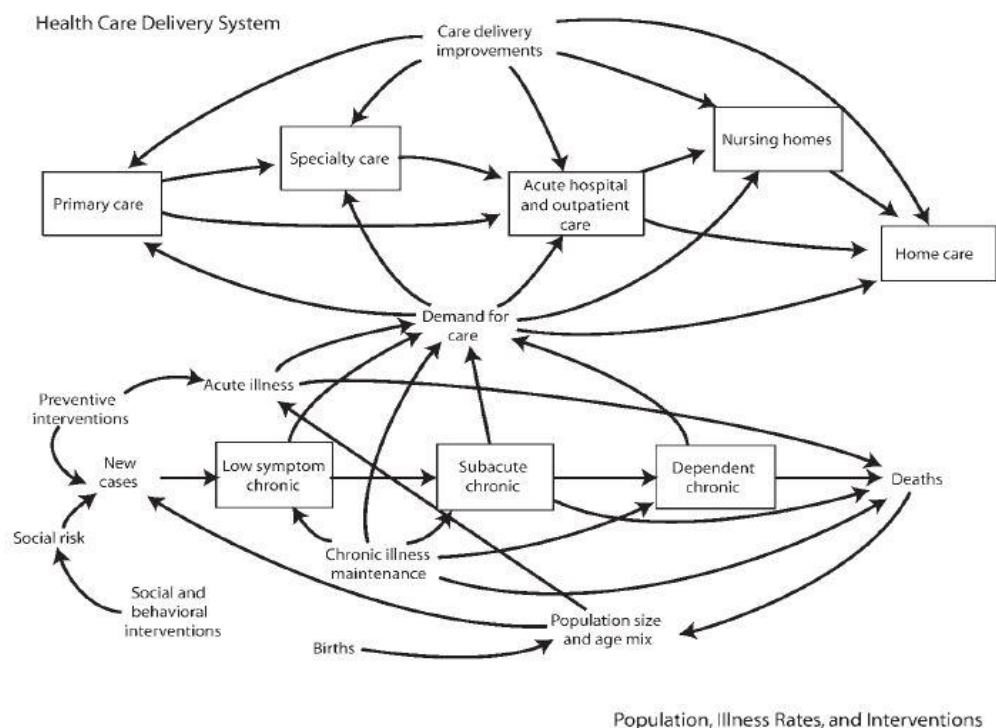
version. In the case of the current research, minimal assumptions were used in the model, due to the use of real data from UPDA and national data sets. This ensured definitive figures for the model and an increase in the chance of comparing scenario outputs appropriately without the need for variance estimations.



#### 4.6.3.4 System dynamics model

System dynamics modelling (SD) could also have been an alternative to the supply and demand model. SD modelling involves the development of computer simulation models that portray processes of accumulation and feedback and that may be tested systematically to find alternative policies (Homer and Hirsch, 2006). It has been proposed that systems dynamics modelling is one of the fastest growing modes of research on the complex relationship between social, environmental, and institutional influences on health behaviours and outcome (Singh, 2012). Singh (2012) argues that system dynamic modelling can be a useful tool in testing real world policies based on an understanding of the causal and feedback mechanisms that exist.

Homer and Hirsch (2006) suggested that SD shows promise as a means of modelling multiple interacting diseases and risks, the interaction of delivery systems and diseased populations, and matters of national and state policy. An example of a hypothetical SD model of prevention for a chronic disease is shown in **Figure 4-13**.



Source: Adapted from Hirsch and Immediato.

Note: Episodes of illness in the bottom half of the diagram determine demand for care in the top half of the diagram. Rectangles in the bottom half represent stocks of ill patients. Rectangles in the top half represent stocks of provider capacity and workload. Arrows represent causal influences.

Source: Homer and Hersch 2006

**Figure 4-13 Homer and Hirsch 2006, model of health care delivery system**

As visible from Homer and Hirsch (2006), SD models are complex and they attempt to include as many aspects within the societal spectrum that may impact on the subject of the model. The models appear to be easier to build and utilise when dealing with a single chronic disease intervention; such as cardiovascular disease (Hirsch et al., 2014) and diabetes (Jones et al., 2006); however the complexity can at times appear imprecise.

An example of some of the earlier SD models in dentistry is shown in the work of Hirsch and Killingsworth (1975), who simulated a model that projected the dental professionals' impact on oral health under a variety of assumptions about manpower policies and supplies, productivity trends and dental benefits. (Hirsch and Killingsworth, 1975). One of the obvious challenges for their model was to focus on one aspect of disease to model. Hirsch and Killingsworth (1975), modelled manpower for symptomatic patients and prevention patients, and this can be challenging to identify in dentistry, because there is overlap in these cases within most patients. The need for distinctive disease groups in a case where demand would need to be modelled to flow in an SD model would be challenging as different patients have different combinations of treatment needs. Including all treatments would make the models complicated. When considering SD for use in this research, this aspect presented as one of the shortcomings of this approach and deterred its use.

More recently SD models have been used to study dental behaviour for specific groups such as older people in order to appropriately plan for their health promotion services (Metcalf et al., 2013). Metcalf et al. (2013) were able to use SD to hypothesize and simulate feedback relationships that link structure with behaviour over time following "what if" scenarios to model the effects of program enhancements and policy changes on the success of their health promotion programme for senior citizens. In Sri Lanka SD models have been used to engage in planning for dental workforce numbers (De Silva, 2012). In England the CfWI (Centre for Workforce Intelligence, 2013, Centre for Workforce Intelligence, 2014b) are using SD models to ascertain the potential for DCPs. They do, however, highlight the challenge in the use of less definitive data and even rank the quality of the data, citing that some data is of low quality (Centre for Workforce Intelligence 2013, 2014).

SD models are complex and these complexities have been criticized. Some find that SD models assumes exhaustive understanding of all factors that interact in a system; which is an almost impossible feat to accomplish (Sterman, 2002). This was another deterrent for the use of this method in this research. The approach in the current research study follows the Ockham's Razor theory of operational modelling, which states 'the best model should not multiply objects needlessly' (Bretthorst, 1996). Bretthorst (1996) adds that 'when two models fit the observations equally well, prefer the simpler model, and this principle has proven itself time and again as a valuable tool of science'. A simple deterministic model was therefore deemed more suitable in this research as the simplicity increases its reliability, transparency and reproducibility (Rajgopal, 2004, Harper et al., 2013).

#### **4.6.4 Cleaning and validation of operational research model data**

The majority of the data used in the actual model were obtained from the NHS BSA using a freedom of information request (NHS Business Service Authority, 2013). The data represented the demand for dental treatment for England in the year 2011/12. These data were processed claims, meaning payments had been made for these treatments; an accompanying documentation highlighted that these were to be appropriately referenced as presented. Any queries in terms of numbers were clarified via email and the integrity of the data was verified.

The data were checked for pattern validity for their applicability to the model. This was done by comparing age related treatment patterns for England to UPDA trends. This method of data profiling was mentioned in the Rahm and Hai do (2013) data validation techniques in Section 4.3.5. The rate of activity by age showed comparability with expected trends for children in prevention and complex treatments for adults. These are shown in the appendix 10.6.22

##### **4.6.4.1 Summary**

The fact that healthcare organisations are in transition from a supply-orientation to a demand driven organisation offers opportunities for operational research (Gallagher and Wilson, 2009, Brailsford and Vissers, 2011). There is room for more research into the organisation of health systems/ health sectors in order to obtain data to inform operational research in order to deal with global health challenges (Royston, 2011). Brailsford and Vissers (2011), propose that the key challenges facing healthcare providers in future years are perhaps more organisational and

logistical than medical and scientific advances and they suggest that operational research provides opportunities to aid in meeting these challenges. By these assertions, simple models that can determine skill mix use on a variety of levels are useful as they enable researchers and policy makers to make informed decisions. In the following section the definitive operational research exercise (Study 5) is described in detail

#### **4.6.5 Study 5] Alternative scenarios for operational research modelling**

This study was developed to address Objective 4.

*Objective 4: to examine the implications of findings from team training experiences for primary dental care nationally and test the potential for skill mix utilisation within NHS dental care*

The process involved operational research techniques undertaken in the following steps

- i. Developing a supply and expressed treatment needs (demand) model informed by findings from UPDA
- ii. Validating timing data for use in the operational model
- iii. Scenario building and testing scenarios based on changes to NHS practice and changing needs
- iv. Cost minimisation analysis for select scenario results.

##### **4.6.5.1 Developing a supply and demand model informed by findings from UPDA**

Some of the relationships that were ascertained between demographic variables and treatment in Studies 1- 4 of UPDA were considered for their applicability to the operational research model intended for national representation. This was undertaken through a process of external validation to justify the use of these findings. First, the relationships between expressed needs and patient socio-demography as identified at UPDA, were compared to similar relationships as ascertained from the Adult Dental Health Survey (2009), which was a nationally representative survey. In addition, the NHS Business Service Authority on age-specific treatment activity data for England were with compared treatment activity in UPDA for the year 2011/12. Following this process only generalizable findings were incorporated into the final model.

The resultant operational model for the alternative scenario testing was referred to as DENTASSim (**D**ental **T**reatment and **S**kill mix **S**imulation). As a whole, the operational model had four components, and was constructed to predict clinical hours, whole time equivalent staff required to deliver the clinical care, and skill mix ratios for dentist to hygiene-therapists based on UPDA skill mix model/delegation rates and future national primary dental care scenarios.

The expressed treatment need for England (17 treatment groups) was input into the spreadsheet model (model stage one); this was age specific and treatment specific. Stage two was the treatment times which were treatment specific and varied between adult and child. Details of the timing are in the next section 4.6.5.2. The Stage three, was the delegation rates from UPDA also input into the excel spreadsheet as age-specific and treatment specific. Final stage of the model also included a separate block on the excel spreadsheet was average work weekly hours and annual leave estimates, specific to hygiene therapist and dentists. The model is full detailed in the results Chapter 8.

#### **4.6.5.2 Validating timing data for use in the operational research model**

Timing is required in human resource operational modelling studies in order to investigate work time requirements (Dreesch et al., 2005). Often, a Delphi exercise using experts is the common method employed to suggest time or time in motion studies (Dreesch et al., 2005, Centre for Workforce Intelligence, 2013). When the output of a model is estimated clinical hours and WTE, as in the present study, timings for treatments are required (Hurst, 2002). Dreesch et al (2005), recommend that these can be obtained by, expert opinions, time in motion studies or patient flow analysis. In this study timings previously derived from primary dental care to inform policy were validated and applied to the model. The original timings were based on an expert panel which estimated treatment time for several dental treatments for the remuneration of GPs in 1999; referred to as the BDA Heathrow Timings because of the location of the work (Bearne and Kravitz, 2000) BDA Heathrow timings have been used in dental workforce modelling studies in England; even recently (Gallagher et al., 2010, Harper et al., 2013, Gallagher et al., 2013). In order to ensure the use of BDA timings were suitable, a validation study was undertaken. Ten separate practicing professionals were asked them to estimate the time for 3 procedures which were not in the Heathrow timings. They were also asked to undertake face

validation of the Heathrow timings for the other 14 treatments. Details of validation template are in appendix

Overall, the BDA Heathrow timings were considered the most helpful for use in this present study, as they were based on the English setting and contained absolute timings for 14 out of 17 treatment groups considered for modelling, despite being based on a previous NHS payment system. Other timings that have been used, have had their accuracy questioned e.g. the WHO timings (World Health Organization 1989), which were derived from pooled data of several treatments, and were not absolute (Murat, 2012). Other timings such as the Panthumvanich et al (1986) timings were country specific and historical. More recently, treatment times calculated within the Malaysian dental service (Murat, 2012) and these were country specific.

#### **4.6.5.3 Scenario building and testing scenarios based on changes to NHS practice and changing needs**

This is a process of identifying the alternative scenarios for the model. It involves clarifying issues, acquiring information, analysing the system, describing the past and present, framing the scenarios and applying these to a model (Garrett, 1999). Operational research facilitates the use of scenarios in a systematic way, as scenarios have the potential to inform planning by providing different 'pictures' of the current or future system (Gallagher, 2002, Garrett, 1999). The scenario building process for this study ensured that it maintained contemporary relevance as outlined by the review of literature. In this study the scenarios considered the use of skill mix in alternative circumstances informed by changing policy and health.

First the scenarios strategy needs to be considered. There are several scenario simulations which can allow prediction, forecasting, foresight, envisioning or testing options (Garrett, 1999, Gallagher, 2002).

- i. Prediction: describing what one aspect of the future is expected to be
- ii. Forecasting: describing several feasible or plausible futures with rather high degrees of probability
- iii. Foresight: looking at a wider range of possible futures, among which may be probable and improbable ones, desirable and non-desirable ones, mixed futures and ones reflecting major trends or events

- iv. Envisioning: imagining one or more futures that are desirable
- v. Testing options: determining futures likely to results from alternative policy choices

In this current study 'testing options' was used to look at a wide range of 'What if?' scenarios, changes in prevention practice by improving the application of guidelines. For example, 'What if the number fluoride varnish applications increased by 50%?' 'What kind of workforce would be required enabling that change?' One of the scenarios relates to the use of skill mix in the advent of changes in expressed demands and regulation (direct access) in NHS dentistry in England. 'What if' scenarios are considered useful in providing flexibility in the estimation of health workforce requirement (Dreesch et al., 2005). The scenarios were as follows:

#### 4.6.5.3.1 Scenario 1: No skill mix

This scenario assumed an unlikely alternative, where all care would be undertaken by dentists only. This is the 'no skill mix' scenario. This scenario is based on a situation that is completely opposite to the new direct access regulation (General Dental Council 2013a). The method used in this scenario simulation has parallels with the work of Gallagher et al. (2010). In their work, Gallagher et al. (2010) explored four scenarios namely: 'no skill mix', where all care for older people was undertaken by dentists, 'opening the door' where clinical dental technicians (CDTs) diagnose and examine, and the final scenario 'denture kings', where all denture work is performed by CDTs. Here all the procedures are completely undertaken by the dentists as all procedures are within their scope of practice.

#### 4.6.5.3.2 Scenario 2: UPDA national

This scenario applies the skill mix practice in UPDA to national demand for services to ascertain the clinical hours and WTE for dentists and hygiene-therapists across England if skill mix was practised in the same way. The underpinning rationale for this scenario is that educational strategies such as team training are introduced with the intention of impacting the practice patterns of the future workforce. It has been suggested that interprofessional training for the dental team should be a fundamental training requirement, the impetus being to improve collaboration between dental team members (Medical Education England, 2011). Evidence has shown that altered curriculum significantly impact career practice. An example is community based dental education, which has been shown to predict the long term practices of dentists

who engage in it during training in dental offices, increasing the likelihood of charity or caring for under-served group (Cunningham et al., 1985, Piskorowski et al., 2012, McQuistan et al., 2014).

#### 4.6.5.3.3 Scenario 3: Direct access

This scenario is based on the new direct access regulation (General Dental Council 2013a). The method used in this scenario simulation is also similar to scenario 1 and Gallagher et al. (2010). It involves altering the proportion of examinations delegated to hygiene-therapists at different rates. This is based on the expectation that direct access widens the scope of DCPs allowing them to perform examinations. The scenario involved 10 simulations, which can be viewed as 10 sub-scenarios; of 10% varying rate of examination delegation between 0% delegation to 100%. The outputs give an indication of the impact of each variation on skill mix. The model still includes the delegation practices/skill mix model for all other procedures. At each simulation that alters the proportion of examinations undertaken by hygiene-therapists the clinical time and WTE for dentists and hygiene-therapists is noted for changes.

#### 4.6.5.3.4 Scenario 4 More prevention

Scenario 3 simulates the impact of an alternative improvement in the provision of preventative care. This is a significant focus for current and future NHS service delivery. As discussed in the introduction and the literature review, prevention and maintaining oral health of the population is a government priority. The pilot contracts are exploring a care pathway that will encourage more prevention, and the release of the latest edition of 'Delivering Better Oral Health (DBOH)' third edition, which is a tool kit of evidence based prevention in primary care (Department of Health and British Association for the Study of Community Dentistry, 2009, Department of Health and British Association for the Study of Community Dentistry, 2007, Public Health England et al., 2014), is likely to have impact on prevention practices such as fluoride varnish treatments. Reports in the past suggested that the rate of fluoride toothpaste prescription increased since delivering better oral health was first introduced in 2007 (Health & Social Care Information Centre, 2013).

This scenarios simulated changes in the proportion of fluoride varnish treatments. For the NHS year in focus 2011/12, 13.1% of children's treatment plans included fluoride varnish (Health and Social Care Information Centre, 2012). In scenario 3, 8 simulations were run, each varying



increases in the proportions of fluoride varnishes from between 20% to 100%. In summary, all the scenarios build on the findings from UPDA and contemporary NHS changes. In the next section the outputs from each of the scenario simulations are presented.

#### 4.6.5.3.5 Scenario 5 Maximum skill mix

This scenario is similar to scenario 1, in that it is an unlikely scenario. Here all work that could be undertaken by the hygiene-therapists is apportioned to hygiene-therapists and the amount of time that could be delegated is ascertained. This scenario provides the visual range at which care can be referred to DCPs.

#### 4.6.5.4 Cost minimisation analysis

The final stage of the operational research exercise involved cost minimisation, which attempted to apply economic aspects to the results provided on expressed treatment need, demography and the proportioning of care between two personnel (dentists and dental hygiene-therapists/hygienists). Economic evaluations of skill mix are underused (Richardson, 1999). In this study economic evaluation was undertaken using a cost minimisation analysis where two alternatives being considered are known to or can be assumed to produce identical outcomes and therefore comparing cost outlines the cheaper option (Neale, 2009). In this study the outcome is clinical time to complete procedures or patient outcomes are assumed to be similar because the quality of work would be the same between either dentists or a DCP. It was assumed that hygiene-therapists and dentists perform at the same rate of speed as well.

The need to manage finite resources within the future NHS is clearly stated in policy documents (NHS England, 2014a). This analysis is done as an adjunct to the other scenarios as it does not cover all aspects of cost associated with the employment of DCPs. Richardson et al. (1998) highlights that establishing cost saving with skill mix begins to provide an indication of improved efficiency. This analysis is not cost-effectiveness analysis because there are no patient outcomes to test; however, with the assumption that the same outcome will be provided due to the same quality between DCP and dentist, it is reasonable to ascertain the amount of saving one option could have over the other.

Following the simulation of WTE staff required to meet dental demand from the operational DENTASSim model, an analysis to investigate the lowest salary cost alternative between the

various scenarios was undertaken. This was by applying the range of salaries for dental therapists and dentists as outlined on the national careers services resource centre (National Careers Service, 2013). Calculating these against the WTE required to meet total expressed treatment need produced to cost alternatives.

#### **4.6.6 Summary**

This chapter has provided the rationale for the methodology employed in this research and also provided a sequential description of the processes that were undertaken in each of the studies. In successive chapters the results are reported. Chapter 5 describes the results from the before and after analysis of patient base and the volume of activity in the four-years. Chapter 6 presents the findings on the relationship between expressed treatment need and socio-demographic characteristic of patients. Chapter 7 reports on the skill mix analysis, providing details of pattern of delegation of tasks and patients. Chapter 8 contains the results of the operational research modelling and describes the findings.

# Chapter 5 Patient base: demography, deprivation and geography

## 5.1 Introduction

This chapter reports on findings from analysis of the pilot (Study 1) and main (Study 2) data sets from UPDA **Figure 5-1**. These studies addressed the first objective of the research outlined below

*Objective 1:* To describe the patient population accessing a primary dental care training establishment in terms of demography, deprivation and geographic area of residence before, and after, the start of team training and the expansion of services.

The first section of the chapter describes the changes in the demography and maps the geography of the patient population across the two-year period involving the transition, i.e. one year before (2009/10) and the first year after UPDA was established (2010/11). The second section shows the relationship between treatment volume and socio-demography of patients, in the four academic years studied. Parts of these findings have been reported in a peer reviewed article and conference abstract shown in appendix 10.6.23

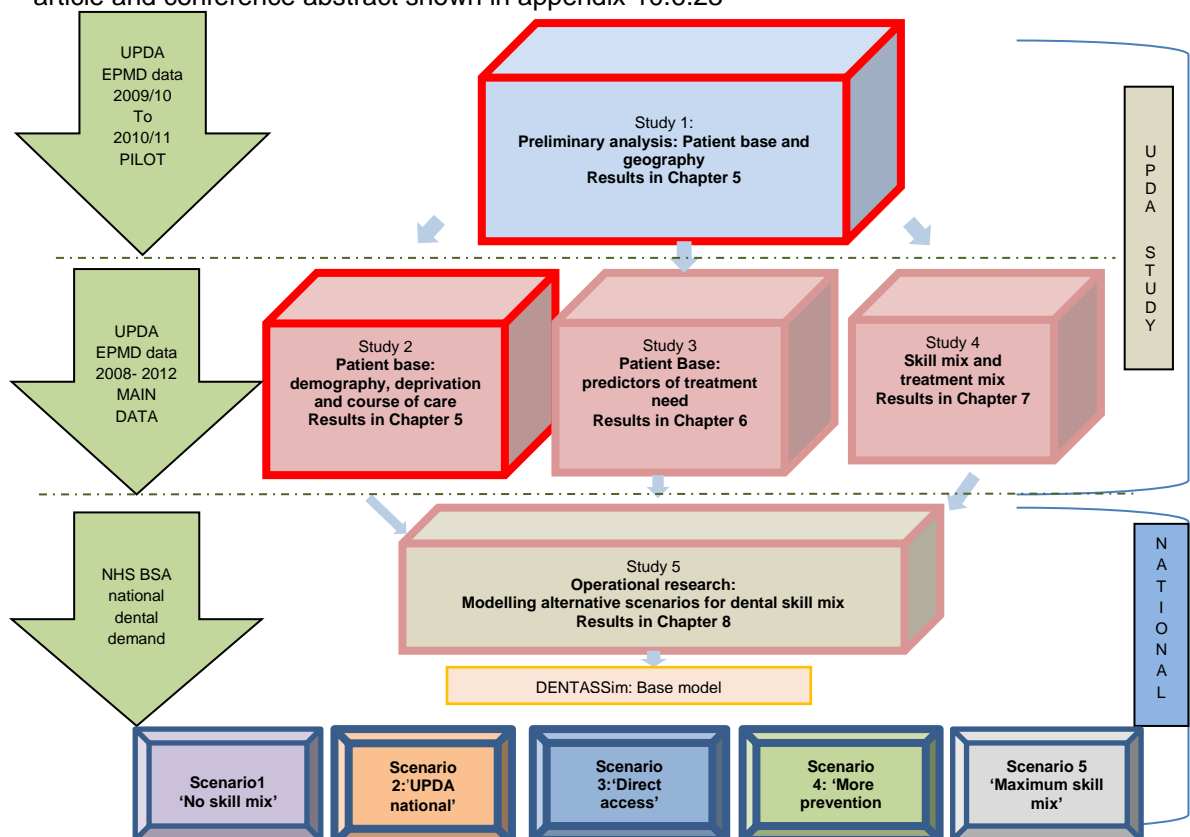


Figure 5-1 Studies: Chapter 5 - study 1 and 2 results

## **5.2 Patient base: pilot data extract for 2009/10 and 2010/11**

The transition from SPCD whereby dental hygiene-therapists trained separately with dental support from the William Beattie Dental Service occurred in the summer of 2010. The pilot data extract therefore involved two academic years' patient management data, i.e. Pre- 01.09.2009-31.08.2010 and Post- 01.09.2010-31.08.2011. As described in the methodology (Section 4.3.3.5), these data were extracted from 'Clinical+' live patient management system using System Query Language [SQL] that restricted the data output to only completed (including closed) treatment plans.

### **5.2.1 Patient volume**

A total of 4,343 patients were included in the analysis. The volume of patients with closed/completed treatment plans in 2009/10 was 1,749 compared with 2,594 in 2010/11, suggesting more single-year completed treatment plans in the year after UPDA expanded.

### **5.2.2 Changes in the volume of different patient types**

Significant differences in the demography and deprivation of the patients were seen between the two years. The demographic variables examined were average patient age, sex, payment exemption status, ethnicity, average indices of multiple deprivation score and average geographical barriers to service access score (a sub-domain of IMD). These results are shown in detail **Table 5-1**.

**Table 5-1 Comparison of patients with completed/closed treatment plans by socio-demography pre-and post- establishment of UPDA**

	Patient characteristics	Academic Year		P value
		2009/10 (n=1,749) Number (%)	2010/11 (n=2,594) Number (%)	
<b>Age</b>	<b>Mean age in years (SD)</b>	31.7 (17.3)	36.4 (19.6)	<b>0.001*</b>
	<b>Age groups</b>			<b>0.001*</b>
	<b>0-2 years</b>	20 (1.1)	22 (0.8)	
	<b>3-5 years</b>	69 (3.9)	95 (3.7)	
	<b>6-12 years</b>	154(8.8)	252 (9.7)	
	<b>13-17 years</b>	80 (4.6)	98 (3.8)	
	<b>18-24 years</b>	355 (20.3)	356 (13.7)	
	<b>25-34 years</b>	386 (22.1)	433 (16.7)	
	<b>35-44 years</b>	316 (18.1)	405 (15.6)	
	<b>45-54 years</b>	180 (10.3)	430 (16.6)	
	<b>55-64 years</b>	100 (5.7)	280 (10.8)	
	<b>65-74 years</b>	60 (3.4)	138 (5.3)	
	<b>75+ years</b>	29 (1.7)	85 (3.3)	
<b>Deprivation</b>	<b>IMD score, mean (SD)</b>	24.5 (14.5)	22.3 (13.8)	<b>0.001*</b>
	<b>IMD Deprivation quintiles</b>			<b>0.001*</b>
	<b>1 =lowest deprivation</b>	323 (18.7)	616 (24)	
	<b>2</b>	311 (18)	471 (18.4)	
	<b>3</b>	341 (19.7)	525 (20.5)	
	<b>4</b>	356 (20.6)	494 (19.3)	
	<b>5=highest deprivation</b>	400 (23.1)	458 (17.9)	
	<b>Median Geographical Barriers to services score (SD)</b>	3.13 (9.2)	4.4 (14.86)	<b>Man Whitney test shows significant difference 0.001*</b>
<b>Ethnicity</b>	<b>Asian</b>	5 (0.3)	35 (1.3)	<b>0.001*</b>
	<b>Black</b>	5 (0.3)	21 (0.8)	
	<b>Chinese</b>	3 (0.2)	5 (0.2)	
	<b>Mixed</b>	1 (0.1)	35 (1.3)	
	<b>Other</b>	19 (1.1)	19 (0.7)	
	<b>Unknown</b>	1,366 (78.1)	1078 (41.6)	
	<b>White</b>	350 (20)	1401 (54)	
<b>Sex</b>	<b>Female</b>	870 (49.7)	1,311 (50.5)	0.314
	<b>Male</b>	879 (50.3)	1,283 (49.5)	
<b>NHS Payment status</b>	<b>Exempt</b>	755 (43.2)	741 (28.6)	<b>0.001*</b>
	<b>Not exempt</b>	994 (56.8)	1853 (71.4)	

Note:

1. Bold p values indicated statistically significant differences in groups  $p < 0.05$  \*SD- standard deviation
2. Data set in use is from the pilot [2009/10 and 2010/11]

#### **5.2.2.1 Age**

The patient age range was the same in both academic years, covering the life course from one to 94 years. The majority of patients in both years were working age adults between the ages of 18 and 64 years. The average age of patients was significantly greater in the new service, increasing from 31.7 years (95%CI 30.8-32.5) in 2009/10 to 36.4 years (95%CI 35.6-37.1) in 2010/11 ( $p<0.005$ ) as shown in **Table 5-1**.

The proportion of children ( $\leq 18$  years) was also similar in the two academic years, with a ratio of children to adults being 1:4. The greatest increase in volume of patients was amongst adults aged 75 years almost tripling from 29 to 85, whilst 18-24 year olds remained similar.

#### **5.2.2.2 Deprivation**

Deprivation status was derived from postcode of residence and IMD score. Analysis suggests that the patient base was less deprived in the post-expansion period; the mean deprivation score (IMD score) of the patient population was 24.5 (95%CI: 23.8, 25.2) in 2009/10, compared with 22.3 (95%CI: 21.7, 22.8) in 2010/11  $p=0.001$ . There was a significant increase in volume of patients across all quintiles of deprivation after the expansion ( $p=0.001$ ); however, the increases were largest in the least deprived quintile (1<sup>st</sup> quintile) which showed a 90.7% increase and lowest in the most deprived (5<sup>th</sup> quintile) with a 14.5% increase.

Analysis of the 'geographical barriers to services' sub-domain of the IMD suggested that patients in the post-expansion period were, on average, less geographically deprived from services than those who accessed the facility in the year before.

#### **5.2.2.3 Ethnicity**

Self-reported ethnicity was low overall. Of the available data, white patients were the largest group in both time periods: 350 (20%) and 1,401 (54%) respectively. However, there was improved reporting over time as the category 'unknown' reduced from 78% to 41.5% in the first year after UPDA was established.

#### **5.2.2.4 Sex**

Sex distribution in both periods was the same with a consistent male/female ratio of 1:1 before and after the service expansion and change.

#### **5.2.2.5 NHS Payment exemption**

The volume of patients exempt from payment was similar in both years. There was a significant difference in exemption status with the volume of non-exempt patients doubling and the proportion of non-exempt patients increasing from 56.8% to 71.4% ( $p=0.001$ ).

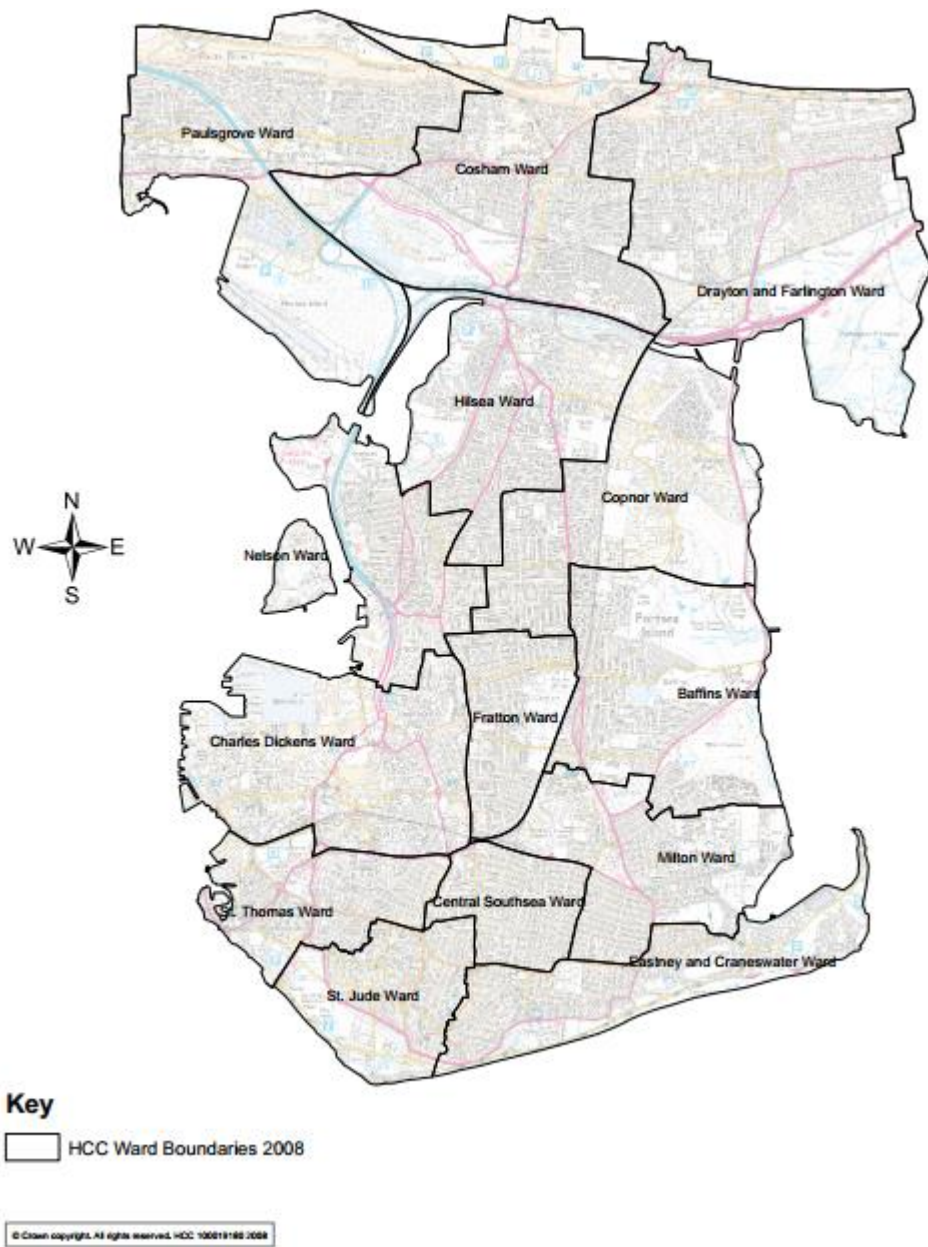
## 5.3 Geographical distribution of patients

The residence of the 4,343 patients, who used the service in the two-year transition period captured in the pilot data, was geographically mapped using Quantum GIS software as outlined in Section 4.4.5.2. **Map 5-1** provides an overview of the wards in Portsmouth. **Map 5-2** describes deprivation in the Portsmouth area. **Map 5-3** provides an indication of the physical features missing from local authority boundary maps, i.e. the inlets/river/roads. The mapping exercise presented in **Map 5-4** was restricted to patients who lived in Portsmouth (green wards) and its environs (purple wards). Approximately (7%) of patients were outside of the area.

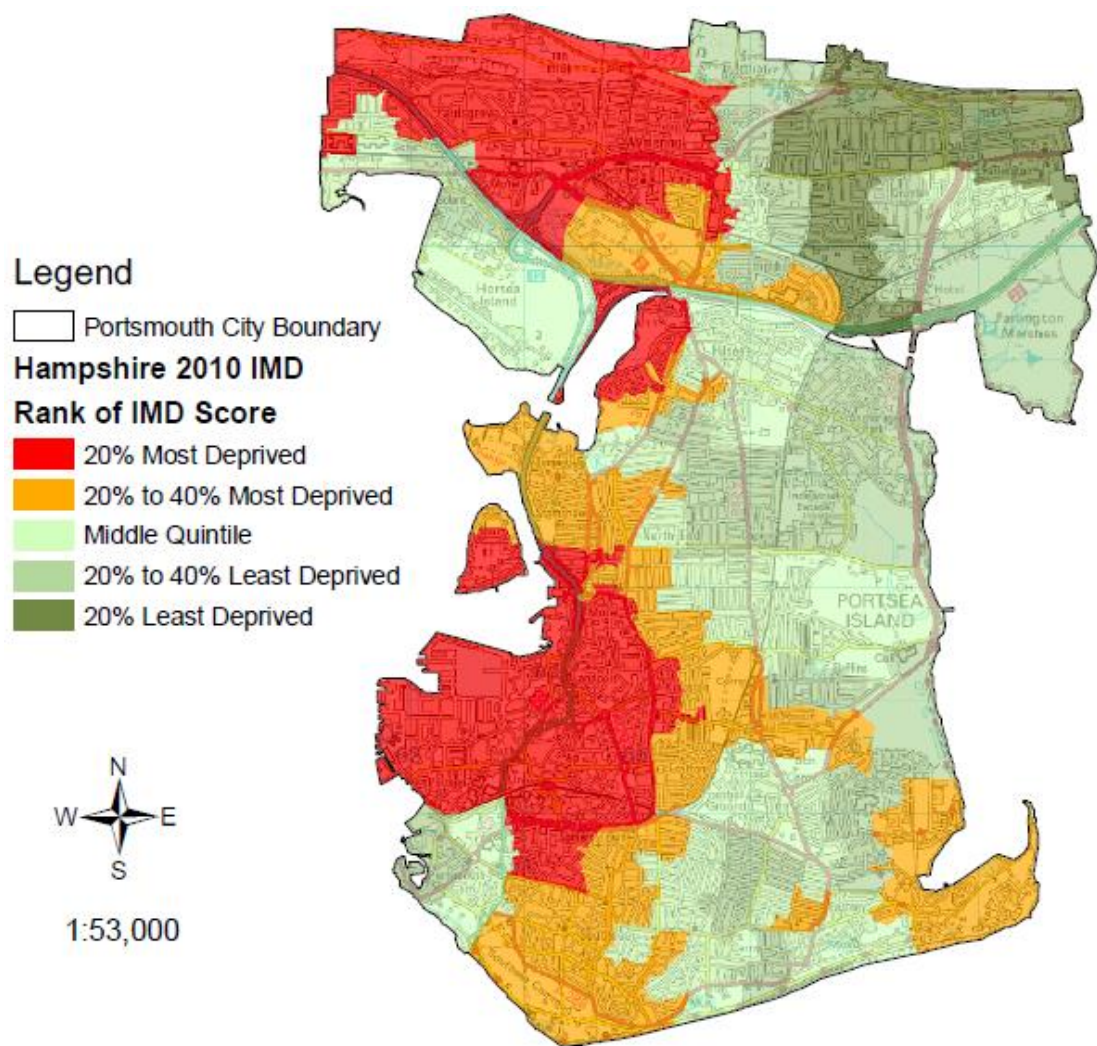
### 5.3.1 Mapping results

The map suggests that patients in the period post-expansion came from a wider catchment area as denoted by the distribution of the red dots and that fewer patients in the post-expansion period came from the most deprived and densely populated wards in Portsmouth i.e. CharlesDickens and Paulsgrove (NHS Dental Public Health Team, 2011). The period before expansion shows a concentration of patients from the community around the Academy. These include Charles Dickens, St Thomas and Central Southsea.





**Map 5-1 Portsmouth area and ward boundaries**



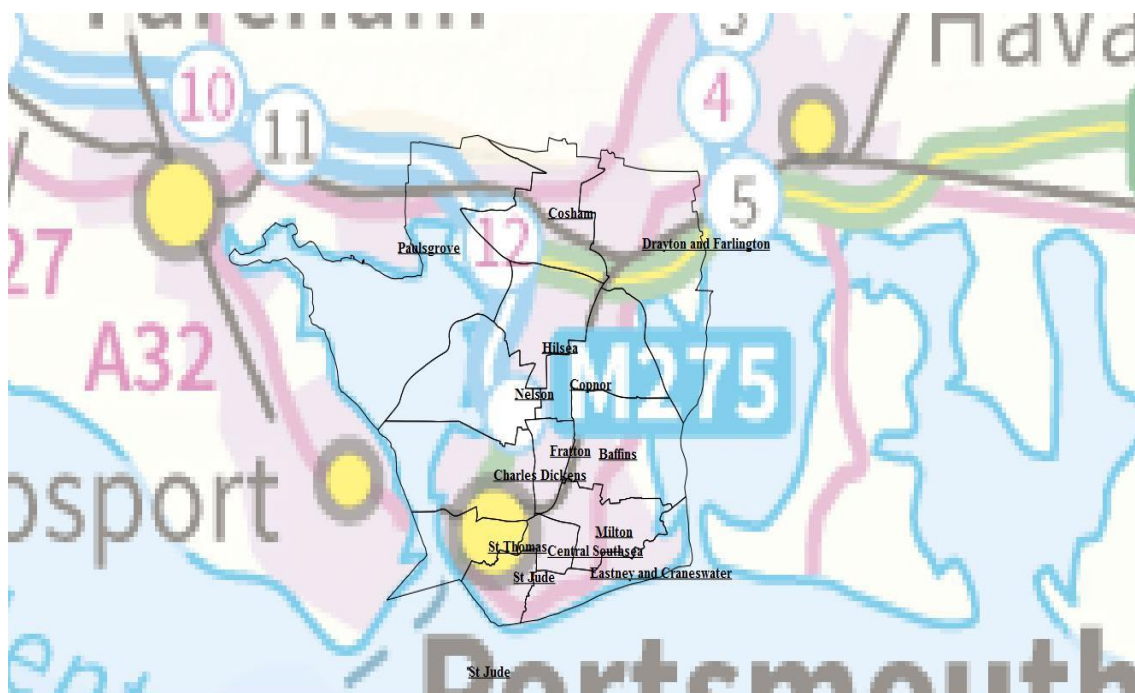
**Note: Deprivation relative to England**



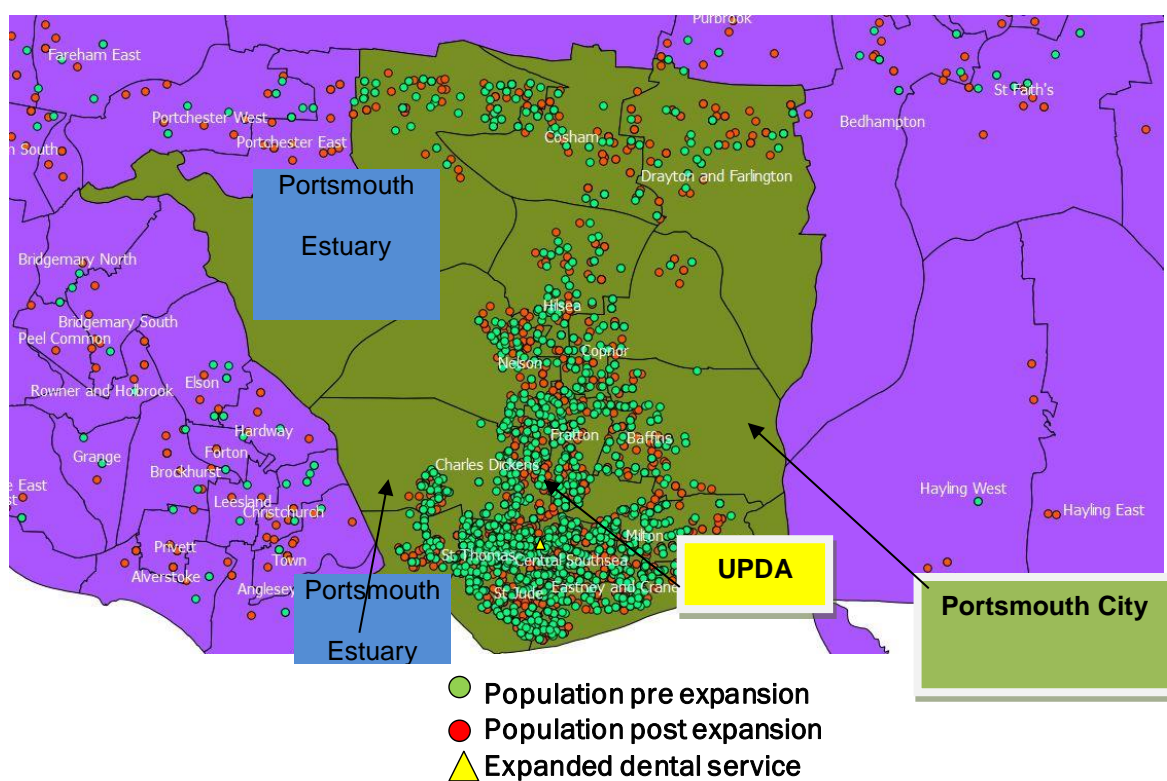
**Source : DCLG 2010**

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**Map 5-2 Portsmouth area, wards and deprivation profile**



**Map 5-3 Portsmouth area, the environs, ward boundaries with physical features**



**Map 5-4 Mapping of patients with completed/closed treatment plans in the 12 months before and after the expansion**

Note:

1. Location of Portsmouth Estuary
2. Portsmouth City Wards in Green
3. Portsmouth Environs in purple
4. **Map 5-3** and **Map 5-4** used in this are reproduced from Ordnance Survey material with the permission of Ordnance Survey on behalf of the Controller of Her Majesty's Stationery Office



### 5.3.2 Geographical deprivation and access

Following the findings of the geographical mapping exercise reported in Section 5.3.1, further analysis of geographical differences using statistical methods outlined in 4.4.5.2 was undertaken using the geographical barriers to services score (GBS score) – a sub-domain of the IMD (Department for Communities and Local Government, 2011) detailed in Section The analysis involved a logistic regression model, which investigated whether geographical deprivation score predicted the period of attendance of the Academy (before or after), while adjusting for other predictor variables. The latter included, age and payment status, which were the two other significant variables in the univariate analysis. Overall, deprivation score (IMD) was excluded from the analysis due to its close relation to the GBS score, ie it is a domain of the former. Furthermore, in order to reduce bias that may arise from including children, who are all exempt from payment, only adult exempt patients were included in the analysis.

The results of the logistic regression displayed in **Table 5-2** which indicates that while controlling for other variables, the strongest predictor of attendance was adult payment exemption status. Adults who had to pay charges (non-exempt status) were 2.7 times more likely to have attended in the post-expansion period.

**Table 5-2 Logistic regression results of patient attendance in post-expansion period [2010/11]**

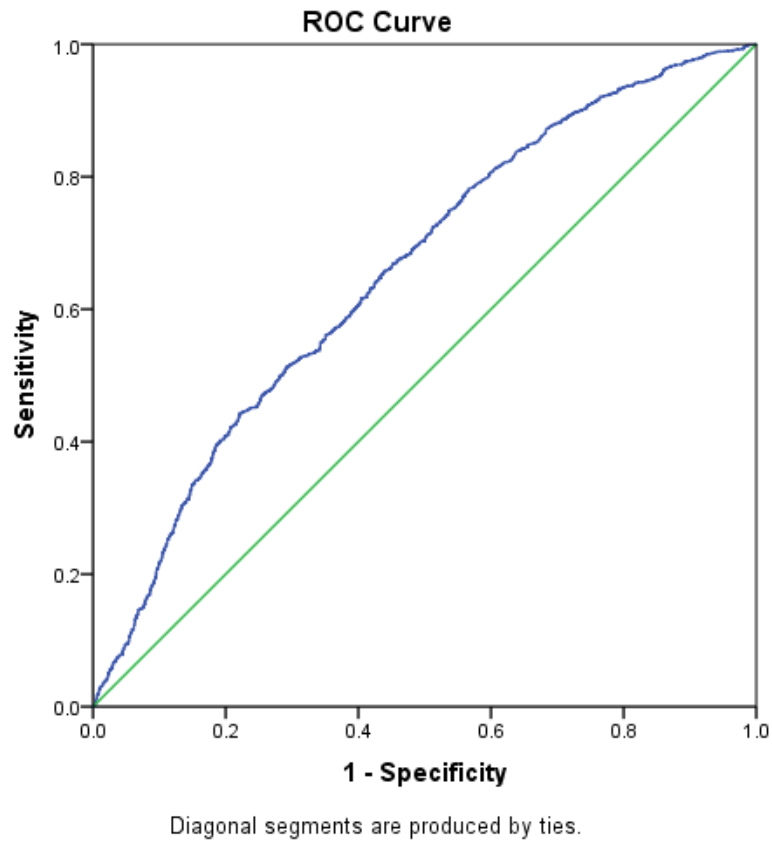
Adults patients n=3,556 Attending in post-expansion period=1	Odds Ratio	95% CI		P-value
		Upper	Lower	
Age	1.021	1.017	1.011	0.000*
Adult payment status	2.798	2.798	3.323	0.000*
Geographical Barriers to services (GBS score)	1.007	1.002	1.012	0.011*

Note: age is a continuous variable: payment status-exemption is reference category: GBS score is continuous variable

Furthermore, the odds of having attended post-expansion increased with every year of age by 2%; OR 1.021 (95% CI: 1.017 to 1.011). Finally, there was an increased likelihood of attending in the post-expansion period for patients with a higher geographical barriers to services score, ie. those further away from services were more likely to attend the new expanded service (0.7%; OR: 1.007 (95% CI: 1.002 to 1.012)).

### 5.3.3 Model validation prediction tests

The ROC prediction test, undertaken to evaluate the performance of the model and to ascertain the predictive power of the binary model, suggests that the model has a moderate predictive power; the results are shown in **Figure 5-2**



Note: The area under the curve is 0.653 above 0.5 validates as having moderate diagnostic powers

**Figure 5-2 Receiver Operator Curve measuring the performance of the Logistic regression model**

## 5.4 Patient volume and type: main data set covering academic years 2008/09 to 2011/12

### 5.4.1 Introduction

This section reports on the findings from the analysis of the 4-year main data extract relating to patients with completed treatment plans as outlined in Section 4.3.4.1 to further address Objective 1. The results reported are as follows: first, trends in volume of completed treatment plans and second, the trend in patient socio-demography within the completed treatment plans.

### 5.4.2 Patients

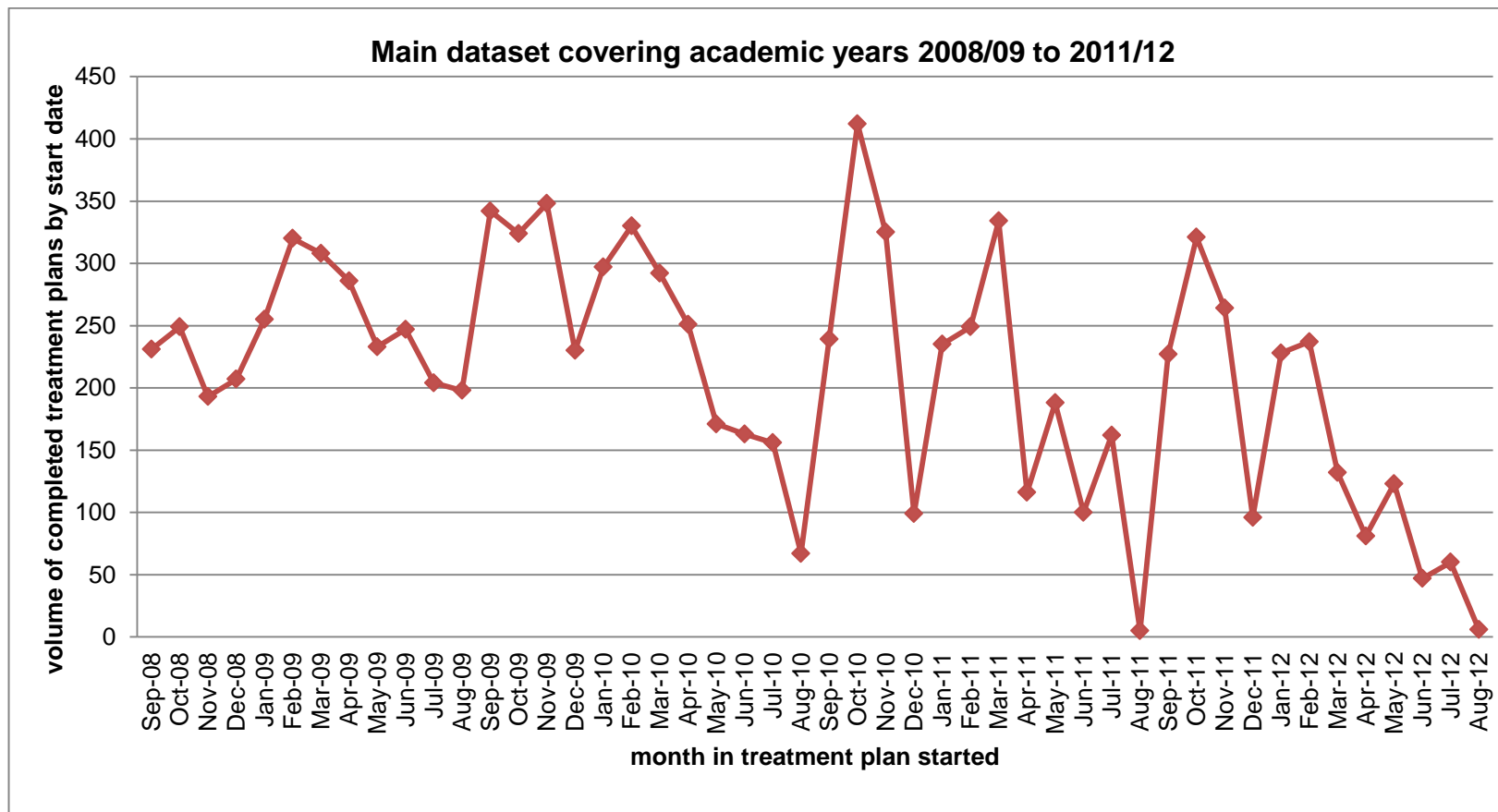
The total number of patients included in the four-year main extract was 6,351. These were patients seen at the facility at least once in the four-year study period. If a patient had multiple completed/closed treatment plans between 2008/09 and 2011/12 academic years, all treatment plans would be included in the analysis.

### 5.4.3 Treatment volumes by academic year

The number of completed treatment plans was 10,371 and the academic years involved were: 2008/09, 2009/10, 2010/11 and 2011/12; meaning each patient completed an average of 1.6 treatment plans in the four-year period.

The first analysis of treatment plan volume shown in **Figure 5-3** graphically shows the volume of completed treatment plans by the academic month in which the treatment plan was **started**. These results are an insight into which months had the highest and lowest number of treatment plans commenced. **Figure 5-4** graphically depicts the results of the analysis of the volume of treatment plans **completed** by academic month and year. *To note:* all treatment plans shown in the graphs were logged as completed or closed, and therefore, more plans may have been started, but if they were not logged as complete, these are not included in the analysis. **Figure 5-4** also indicates the periods in the four-years with the highest rate of treatment plan completion. The results from **Figure 5-3** shows that the treatment plans included in the analysis were started at the highest rate in the first month after the academy was established (October 2010); with over 400 treatment plans started in that month only. The months of July and August in the period after UPDA was established have little to no treatment plans started. In **Figure 5-4** the majority of treatment plans were completed in the months of March and April, which is the

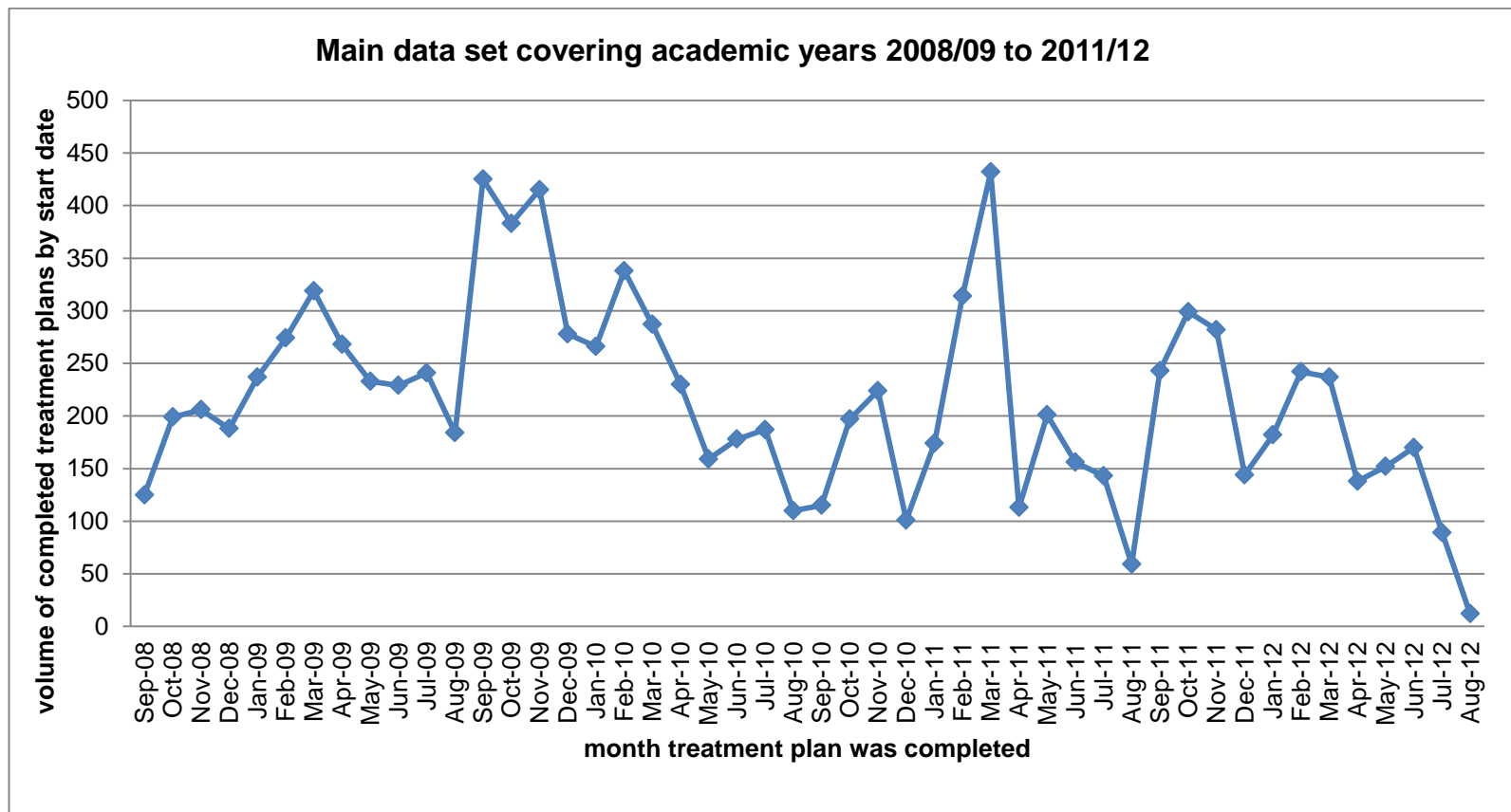
NHS year closing months. These particular analyses were useful in validation of the electronic data showing expected trends in flow of care in such a facility. This type of validation/verification was outlined in section 4.3.7.3.



Note: main data set [covering academic years 2008/09 to 2011/12] used and is of treatment plans completed in the four academic years with patient treatment plan allocated to academic year a treatment plan was started. No. of treatment plans =10,371

**Figure 5-3 volume of treatment plans completed in the four-years by the month and year of the treatment start**





Note: main data set [covering academic years 2008/09 to 2011/12] used and is of treatment plans completed in the four academic years with patient treatment plan allocated to academic year a treatment plan was completed. No. of treatment plans =10,371

**Figure 5-4 Treatment plans completed in the study period by academic month and year of completion**

#### 5.4.4 Re-attendance of patients

As detailed in Section 4.4.6.3 the trend in volume of treatment is counted by closed/completed treatment plans, which could have been more than one treatment plan per patient. In the following results, the number of patients who completed a treatment plan in more than one academic year is reported. This is described as the re-attendance pattern. It should be noted that if a patient had at least one closed treatment plan in one academic year, this is only counted once. Re-attendance is only a description of revisit to the Academy in two or more of the academic years covered by the study and gives an indication of the type of service, whether patients consider it a stabilising facility or use a regular practice. The results are shown below in **Table 5-3**.

**Table 5-3 Repeat visits for patients**

<b>Number annual check-ups within the four years</b>	<b>Frequency</b>	<b>Per cent</b>
<b>one</b>	3,868	60.9
<b>two</b>	1,451	22.8
<b>three</b>	710	11.2
<b>four</b>	322	5.1
<b>Total</b>	6,351	100.0

Note: Data set in use: treatment start-date- i.e patients allocated to academic year in which a last started a course of care [Main data set covering academic years 2008/09 to 2011/12]

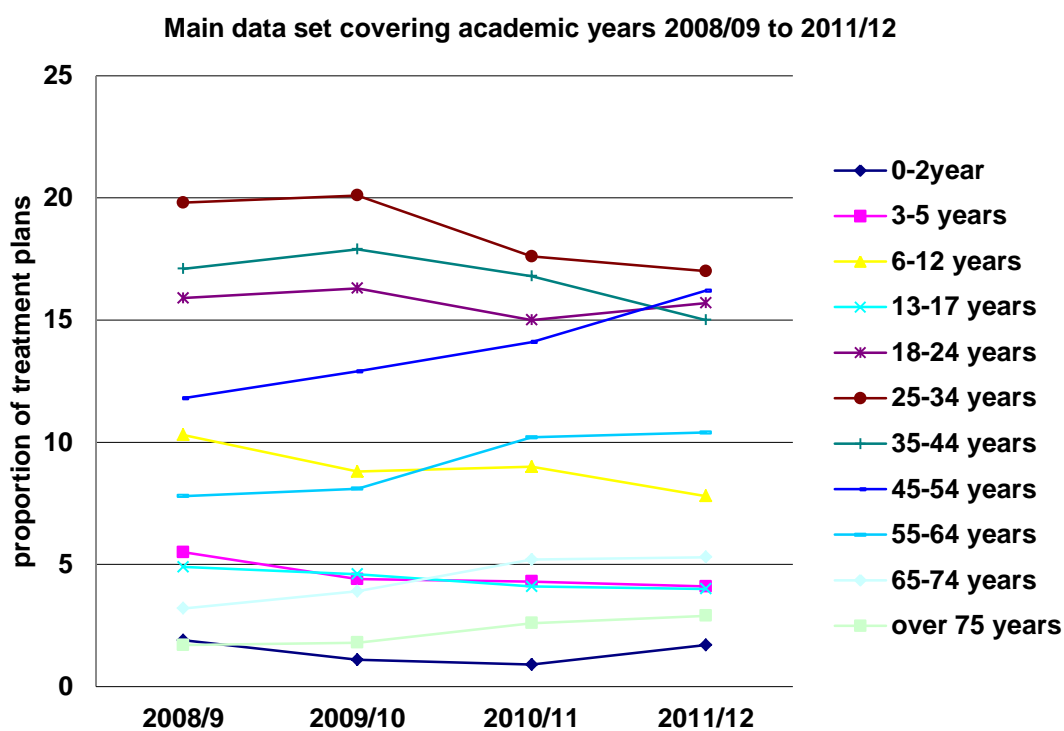
From the results shown, the majority of patients (60.9%) were treated in one academic year only. These findings should be considered in the context of the cross-sectional nature of the data set, while also considering that only completed treatment plans are included in the analysis.

### 5.4.5 Patient socio-demography in academic years

This section reports on the volume of patients by socio-demography who received each completed treatment plans in the four academic years. The socio-demographic variables used to describe patients were age, deprivation, ethnicity, sex, payment status and smoking status. A treatment plan was assigned to the academic year in which it was completed in order to ascertain a yearly trend in volume. The total number of unique patients included in the study remained 6,351. The total closed/ completed treatment plans analysed were 10,371.

#### 5.4.5.1 Age and completed treatment plans

The volume of completed treatment plans in each academic year was distributed by eleven NHS age groups. Indicating the proportion of the total completed/closed treatment plans, in each academic year, were undertaken on patients from each age group. Below is a line graph of the results of this analysis.



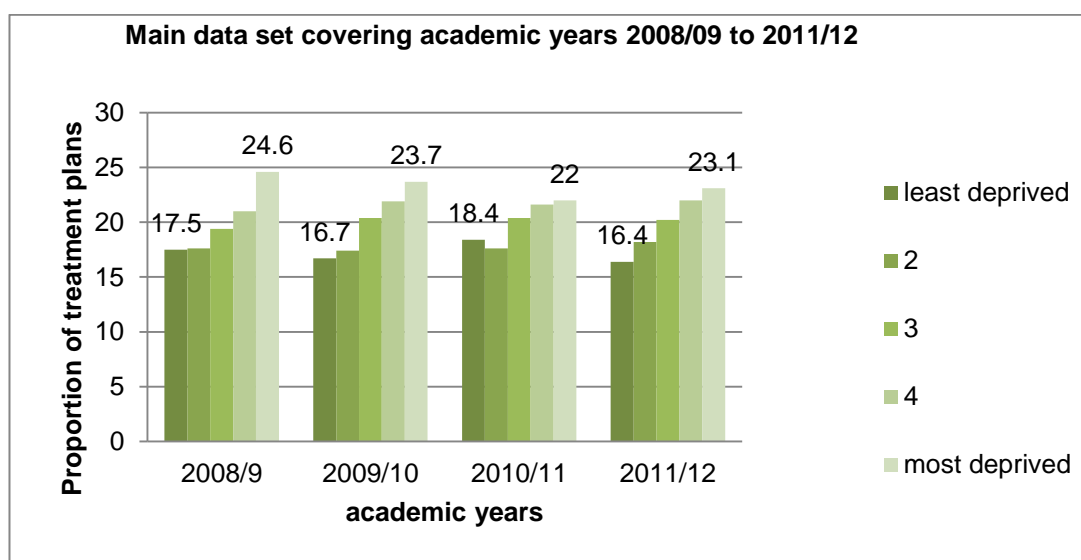
Note: main data set [covering academic years 2008/09 to 2011/12] used and is of treatment plans completed in the four academic years with patient demography allocated to academic year a treatment plan was completed (this may mean a patient demography counted twice if they completed more than one treatment plan in an academic year) no. of treatment plans =10,371

**Figure 5-5 Proportion of different age-bands within completed treatment plans in the four years**

**Figure 5-5** showed that in each of the four academic years, the 25-35 year old age group had the highest proportion of completed treatment plans. This age group's proportion in the two years after expansion reduced from 20% to 17%. The 45-55 and 54-65 year-old age groups had a linear increase in representation across the years. The 65-74 year group, although among the lowest in proportion (under 5%) in all years, does increase in proportion to the total treatments, in the two years post-expansion into UPDA and team training.

#### 5.4.5.2 Deprivation

The most deprived quintile in the Primary Care Trust (PCT) had the highest proportion of completed treatment plans in each of the four academic years. The results are shown in **Figure 5-6**.



Note: main data set [covering academic years 2008/09 to 2011/12] used and is of treatment plans completed in the four academic years with patient demography allocated to academic year a treatment plan was completed (this may mean a patient demography counted twice if they completed more than one treatment plan in an academic year). No. of treatment plans =10,371

**Figure 5-6 Proportion of different quintiles of deprivation within completed treatment plans in the four years**

From the graph in **Figure 5-6** a step gradient of the proportion of patients by quintile of deprivation is evident within each year. It should be noted that (deprivation quintile was based on the Quintile of deprivation of the patients' residence in the PCT and NOT by the sample). With the exception of the academic 2010/11, which was the first year post-expansion into UPDA, the step relationship where the most deprived have the most number of treatment plans

and the least deprived the least, is maintained. In 2010/11 there is a surge in the least deprived quintile over the second least deprived. The step-like relationship is restored in the second year post-expansion.

#### 5.4.5.3 Ethnicity

The reporting of ethnicity was low throughout the four-years, but steadily increased with each academic year. **Figure 5-4** shows the distribution of ethnicity within the closed/completed plans in the 4 years. Of the known ethnicity, patients reported as White had the highest proportion of completed treatment plans in all years.

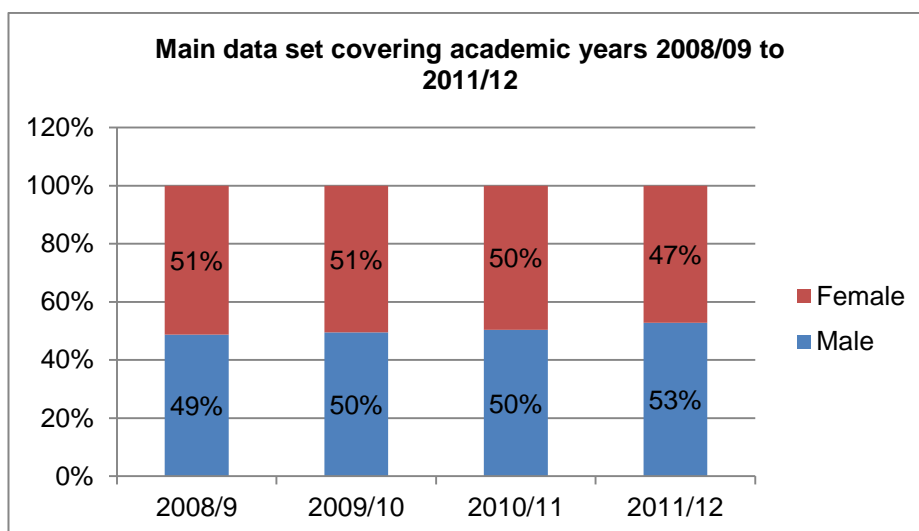
**Table 5-4 Proportion of treatment plans by ethnic groups over four academic years**

Ethnicity	2008/09 (%)	2009/10 (%)	2010/11 (%)	2011/12 (%)
Asian	15(0.6)	27 (0.8)	34(1.5)	51(2.3)
Black	4 (0.1)	12(0.4)	18 (0.8)	27(1.2)
Mixed	11(0.4)	19 (0.6)	33(1.5)	36 (1.6)
Other	14 (0.5)	38 (1.2)	24 (1.1)	15(0.7)
Unknown	1,924(71.2)	1,948(59.8)	787(35.3)	584 (26.8)
White	735 (27.2)	1,212 (37.2)	1,333 (59.8)	1,470 (67.3)

Note: main data set [covering academic years 2008/09 to 2011/12] used and is of treatment plans completed in the four academic years with patient demography allocated to academic year a treatment plan was completed (this may mean a patient demography counted twice if they completed more than one treatment plan in an academic year) no. of treatment plans =10,371

#### 5.4.5.4 Sex

The treatment plans were investigated for sex proportions in order to ascertain whether more male or female treatment plans were common in the data. **Figure 5-7** below shows details.



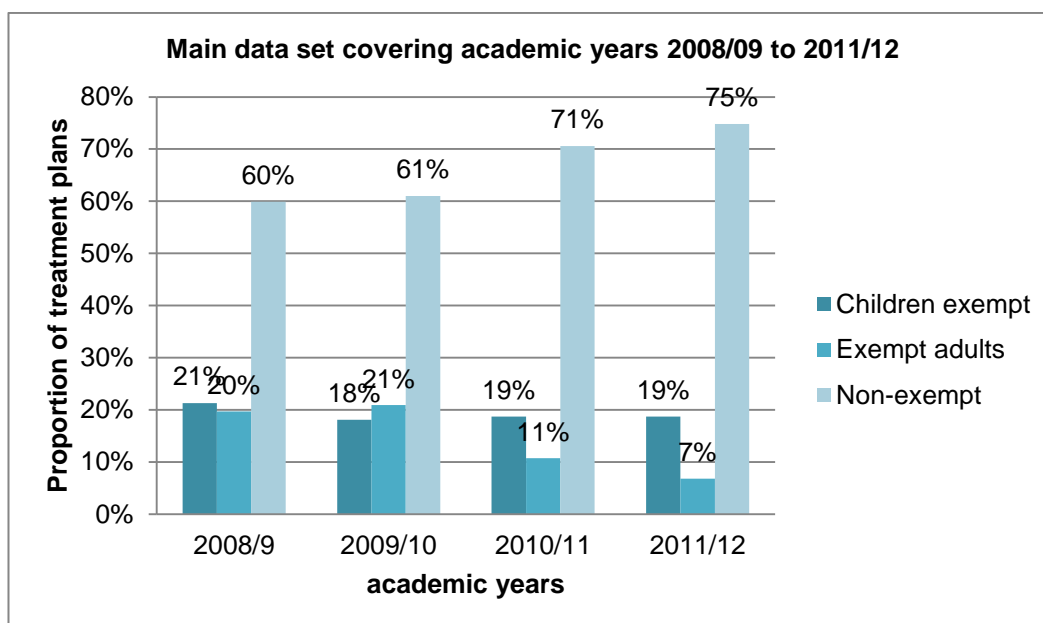
Note: main data set [covering academic years 2008/09 to 2011/12] used and is of treatment plans completed in the four academic years with patient demography allocated to academic year a treatment plan was completed (this may mean a patient demography counted twice if they completed more than one treatment plan in an academic year) no of treatment plans =10,371

**Figure 5-7 Proportion of different sexes within completed treatment plans in the four years**

The results indicated that male patient treatment plans were consistently increasing as a proportion of all treatment plans as the academic years progressed; from 48.8% in the 2008/09 academic year to 52.8% in the 2011/12 academic year.

#### **5.4.5.5 Payment exemption status**

It was important to investigate payment exemption status across the treatment plans in the four years and this analysis indicated that the proportion of treatment plans conducted on exempt adult patients gradually decreased from 21% in 2008/09 to 7% in the 2011/12 academic year. Non-exempt patients' treatment plans are distinctively higher in proportion in the years after UPDA was established. Children treatment plans were placed in their own category, because all children are exempt from payment. See figure 21.

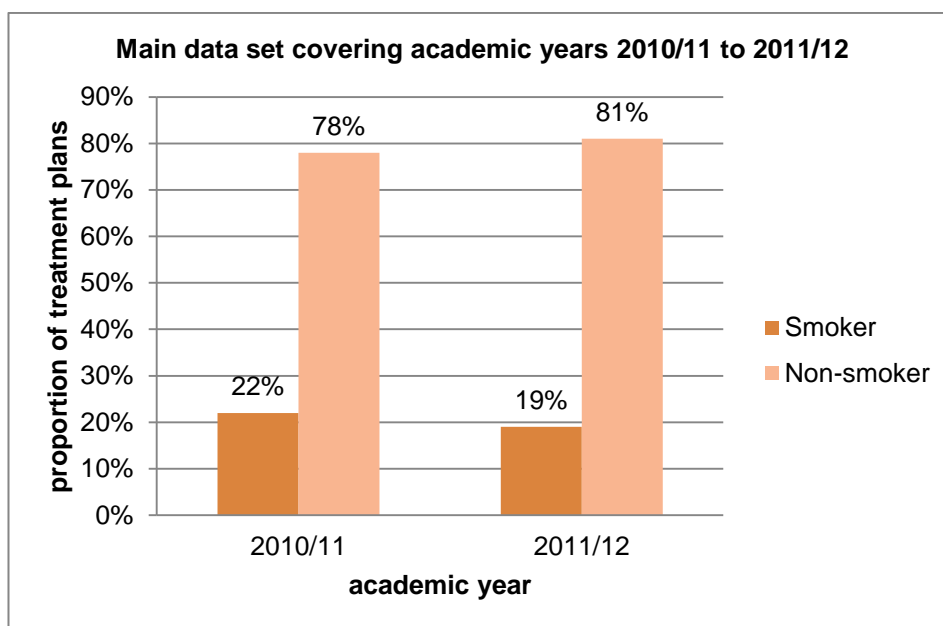


Note: main data set [covering academic years 2008/09 to 2011/12] used and is of treatment plans completed in the four academic years with patient demography allocated to academic year a treatment plan was completed (this may mean a patient demography counted twice if they completed more than one treatment plan in an academic year) no. of treatment plans =10,371

**Figure 5-8 Proportion of different payment status within completed treatment plans in the four years**

#### 5.4.5.6 Smoking status

Smoking is a risk factor for several chronic illnesses. Patients who are smokers and signposted to smoking cessation could be identified within the extracted data in the two years post-expansion to UPDA. The results show that the proportion of patients signposted to smoking cessation because they were identified as smokers was 22% in 2010/11 and 19% in 2011/12.



Note: main data set [covering academic years 2008/09 to 2011/12] used and is of treatment plans completed in the two academic years with patient smoking status allocated to academic year a treatment plan was completed (this may mean a patient demography counted twice if they completed more than one treatment plan in an academic year). No. of treatment plans =10,371

**Figure 5-9 Proportion of different patients signposted to smoking cessation (known smokers) within completed treatment plans in the four years**



## **5.5 Summary of findings**

The results reported in this chapter provide an overview of the patient base using the service prior to, and following the service expansion. The pilot UPDA electronic patient management data extract facilitated the investigation of the patient base in the year before and year immediately after the expansion and the main data set enabled the analysis of trend in volume of completed treatment plans in each of the four academic years under study by the socio-demography of patients.

### **5.5.1 Overall patient base**

The patient base from the period before and after UPDA's establishment included the full spectrum of age, sex and deprivation in the population. The majority of who were working age adults. Patients were aged between 1-94 years and both males and females were represented in the data. The five quintiles of deprivation derived from IMD were all present in the patient base.

Below is a summary of the findings in this chapter:

1. Pilot: two-year data extract - socio-demography (including mapping)
2. Pilot: two-year data extract – geographical variations
3. Main study: four academic years – trend in socio-demography within completed/closed treatment plans.

### **5.5.2 Pilot: two year data extract- socio-demography**

The pilot extract showed that within a year of expansion into UPDA (academic years 2009/10 and 2010/11), there was a 48% increase in patients with a completed or administratively closed plan. The increase in patient numbers varied within different age groups; with the over 75 year age group having the highest increase. The working-age adults were over 70% of the population in both years. The results also show that the patients non-exempt from services NHS charges 2.7 times more likely to attend in the period post-expansion than the period before. The deprivation profile of users changed, with a higher influx of patients from less deprived quintiles (90%) compared with the most deprived quintiles (14.5%).

### **5.5.3 Geographical variations**

Geographical variations were seen in the residence of patients between the two academic years. Patients from the period after UPDA's establishment were more likely to be more geographically deprived from services than those who attended before UPDA. The mapping of residence showed that patients in the pre-expansion period were from a closer catchment area to the Academy and from the deprived areas of Portsmouth. Those from the post-expansion period were from the environs of Portsmouth.

### **5.5.4 Main study: patient socio-demography and closed/completed treatment plans in the four years**

The analysis trends in the completion and start of treatment plans in the four-years shows that the annual peak for treatment plans completed was in the months of March/April, towards the end of the NHS contract year. And the start of treatment plans was highest in the month of October 2010, which happens to be the month after the Academy expanded. The peaks and the troughs in the trends in completion of treatment plans coincide accurately with the months in which the facility was closed for holidays or just opening. Re-attendance analysis revealed that 60% of patients, 3,868 patients out of 6,351, were seen in a single academic year.

Analysis of completed treatment plans and socio-demography showed a continued increase in the proportion of treatment plans on 45-54 year olds and 54-64 year olds into the years after UPDA. Deprivation of the patient population as measured by mean IMD score and quintiles of deprivation within the PCT showed that the proportion of patient treatment plans from the least deprived quintile of deprivation had the highest volume increase in the first academic year after expansion (2010/11). In other years deprivation quintiles assumed a step trend; where the most deprived groups had the highest proportion of treatment plans. Ethnicity reporting was poor, but improved in the post-expansion period. Treatment plans that were received by male patients increased slightly in proportion in the academic years after expansion into UPDA. Closed/completed treatment plans on non-exempt adults were higher than adult exempt patients in the post-expansion years. Smoking status in the two years post-expansion - as ascertained by smoking signposting - was 22% and 19% respectively.

## Chapter 6 Patient base: predictors of treatment need

### 6.1 Introduction

This chapter reports on the findings from main data extract (Figure 6-1) and presents Study (3) results. The data cover the four-year period 01/09/2008 and 31/08/2012 in SPCD/UPDA. These results address the following study objective:

*Objective 2:* To investigate the relationship between patient socio-demography and treatment received during course of care and over time.

The first section of this chapter describes the patient characteristics and treatment activity. The second section characterises the relationship between treatment volume and socio-demography of patients, using univariate and multivariate analysis.

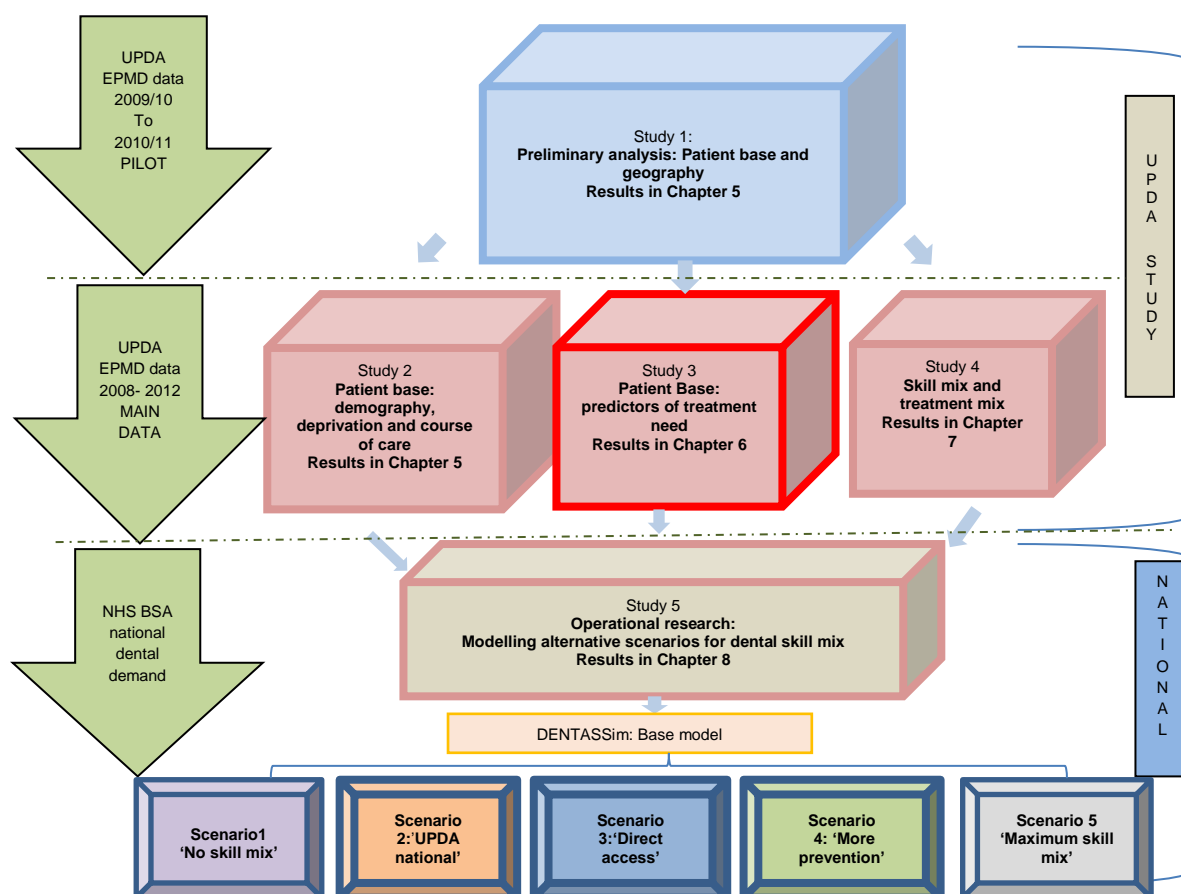


Figure 6-1 Study 3 results

## 6.2 Patients and treatments

### 6.2.1 Patients

A total of 6,351 patients were in the main data set covering academic years 2008/09 to 2011/12.

The age range across the four-year period was 1-94 years.

**Table 6-1 Characteristics of patients in main data set, 2008/09 – 2011/12 UPDA data**

Variables		Frequency	%
<b>Adult exemption status (n= 5185)</b>	<b>exempt adult</b>	1005	19.4
	<b>non-exempt adult</b>	4180	80.6
<b>Age groups</b>	<b>0-2yrs</b>	85	1.3
	<b>3-5yrs</b>	247	3.9
	<b>6-12yrs</b>	541	8.5
	<b>13-17yrs</b>	274	4.3
	<b>18-24yrs</b>	1,211	19.1
	<b>25-34yrs</b>	1,272	20
	<b>35-44yrss</b>	1,008	15.9
	<b>45-54yrs</b>	813	12.8
	<b>55-64yrs</b>	494	7.8
	<b>65-74yrs</b>	260	4.1
	<b>over 75yrs</b>	146	2.3
<b>Quintile of deprivation (n=6259)</b>	<b>most deprived</b>	1,477	23.3
	<b>2</b>	1,318	20.8
	<b>3</b>	1,414	22.3
	<b>4</b>	1,314	20.7
	<b>least deprived</b>	736	11.6
<b>Sex</b>	<b>Female</b>	3,098	48.8
	<b>Male</b>	3,253	52.2
<b>Smoking cessation signposted (n=3436)</b>	<b>non-smoker</b>	2,803	81.6
	<b>smoker</b>	633	18.4

Note:

1. UPDA data includes SPCD data from 2008/09 and 2009/10
2. n=6,351 unless otherwise stated

### 6.2.2 Treatment volumes

147,417 treatment items were completed in 10,371 treatment plans over the four academic years. As outlined in section 4.4.7, patients could have had more than one treatment plan in the data. The data included a higher level descriptor of treatment items, referred to as NHS treatment titles. An example of an NHS treatment title is restorations or fillings, and this encompassed amalgam fillings class 1 or 2, GIC fillings, composite fillings etc. In total there were 69 NHS treatment titles. These are listed in Appendix. **10.6.9.** Out of 69 listed treatment

titles in the data set, 65 were selected for analysis. Exam/assessments (277,256 in number), and three other items were excluded due to systematic duplication errors as explained in detail in methods (Section 4.3.7.2).

Analysis of these NHS BSA treatment titles suggested that the most common was instruction advice (n=36,193) across completed/closed treatment plans. **Table 6-2** shows the most frequently occurring NHS treatment titles in descending order, with just 20 treatment titles accounting for 97% of all the recorded care.

**Table 6-2 Twenty most frequent NHS treatment titles by frequency and volume, 2008/09-2011/12**

<b>NHS BSA 'Treatment' Titles in clinical + patient management system</b>	<b>Total number of treatment items</b>	<b>Proportion of total 65 NHS treatment titles</b>
<b>Instruction / Advice</b>	36,193	25.6
<b>Tooth restorations</b>	21,947	15.5
<b>Topical Fluoride Preventative considered (yes/no)</b>	15,586	11.0
<b>Periodontology: Non–Surgical procedure</b>	14,179	10.0
<b>Radiographs Intra Oral</b>	11,615	8.2
<b>Scale / Polish</b>	10,749	7.6
<b>Colour Photographs</b>	9,424	6.7
<b>Simple tooth extractions</b>	5,009	3.5
<b>Radiograph: Pan-oral</b>	3,091	2.2
<b>Sealant restorations</b>	3,041	2.2
<b>Fissure Seal Preventative</b>	2897	2.0
<b>Dressings</b>	1,732	1.2
<b>Endodontics</b>	1,579	1.1
<b>Denture Partial Acrylic</b>	1,090	0.8
<b>Urgent treatment of acute mucosal condition</b>	743	0.5
<b>Crown Porcelain Bonded</b>	723	0.5
<b>Study Casts</b>	481	0.3
<b>Bridge Alloy</b>	465	0.3
<b>Denture Addition</b>	434	0.3
<b>Crown Repair / Re-fixing</b>	415	0.3

Note:

1. UPDA data include SPCD data from 2008/09 and 2009/10

2. n=6,351 unless otherwise stated

'Instruction and advice' was the most frequently undertaken item of care. This involves tooth brushing advice, dietary advice and disease prevention advice. 'Topical fluoride preventative considered (yes/no)' was considered for 54.3% of children and 41.3% of 18-64 year old patients and 56.6% of those aged 65 years and over. 'Denture addition' is the repair or addition of an

acrylic tooth onto an existing denture. 'Periodontology: non-surgical procedures' involve plaque removal and root calculus removal procedures. It differs from scale and polish as it involves sub-gingival operations and is treatment for patients with periodontitis.

### 6.3 Treatment and socio-demography

The most frequent treatment titles shown in **Table 6-2** were analysed for occurrence per patients. The results are presented in **Table 6-3** as the proportion of all patients (6,351) who received any of the treatment items at least once in the four-year study period. This will be referred to as the 'rate of treatment occurrence' in other parts of this chapter.

**Table 6-3 Rate of occurrence of treatment titles**

<b>Treatment</b>	<b>Proportion of patients who had received the treatment item at least once in the four-years (%) n=6,351</b>
<b>Tooth restorations</b>	51.5
<b>Instruction/ Advice</b>	49.2
<b>Scale and Polish</b>	38.7
<b>Periodontology:non-surgical</b>	31.8
<b>Tooth extractions</b>	25.1
<b>Fissure sealants</b>	13.1
<b>Endodontics</b>	6.6
<b>Partial Dentures</b>	5.1
<b>Crown and Bridge</b>	2.8

Note:

1. UPDA data include SPCD data from 2008/09 and 2009/10
2. n=6,351 unless otherwise stated

Tooth restorations were the most commonly received treatments in this sample of patients, followed by the treatments that support the health of the periodontium, i.e. instruction/ advice, scale and polish and 'periodontology: non-surgical'. These nine treatments were further selected for univariate analysis due to their high frequency, which increased the likelihood of obtaining distribution between all the different socio-demographic categories which would aid unbiased analysis.

## 6.4 Univariate analysis results: socio-demographic predictors of patient treatment needs

This section reports the findings of the univariate analysis. The analysis involved chi-square tests of significance and the data are described in the following sections.

### 6.4.1 Tooth restorations

Tooth restorations had the highest rate of occurrence per patient, with 51.5% of the patients having received at least one tooth restoration in the four academic years. The findings suggest that a significant association exists between the rate of occurrence of tooth restoration and patient age, sex and smoking status. The details are shown in **Table 6-4**,

**Table 6-4 Group difference in proportion of patients who had received a tooth restoration between 2008/09 and 2011/12 academic years**

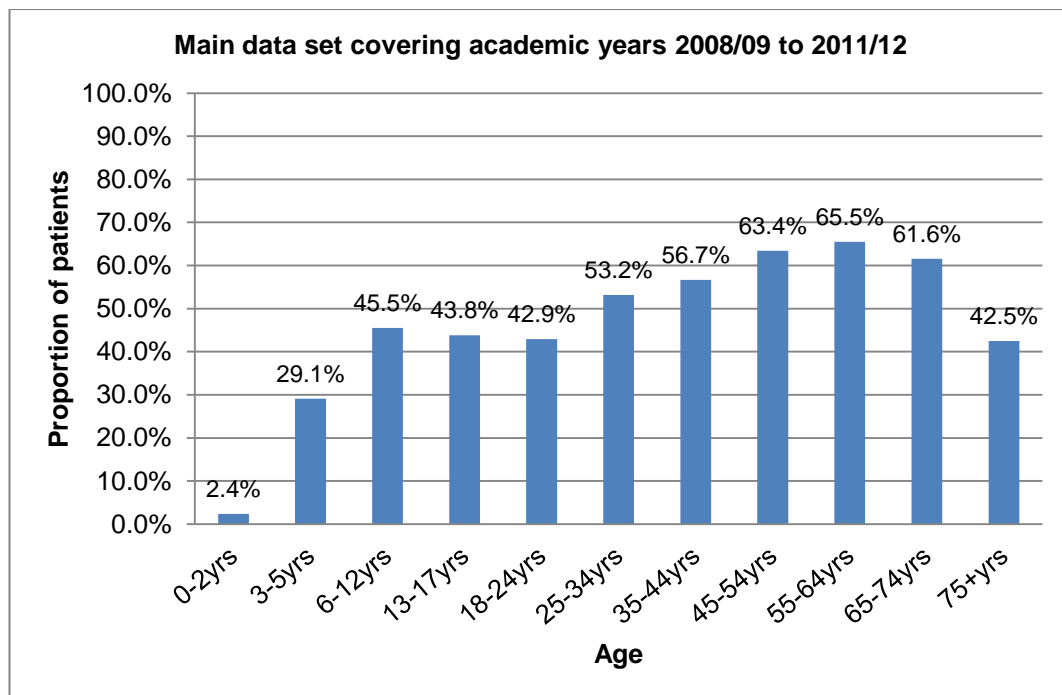
Tooth restorations		No tooth restorations N (%)	Tooth restoration N (%)	P value
<b>Overall</b>	<b>Overall</b>	3,083 (48.5)	3,268(51.5)	
<b>Adult payment status(n= 5,185)</b>	<b>Exempt</b>	475 (47.3)	530 (52.7)	0.236
	<b>Non-exempt</b>	1,889 (45.2)	2291(54.8)	
<b>Age groups</b>	<b>Under 18</b>	707 (61.6)	440 (38.4)	<b>0.001</b>
	<b>18-64 years</b>	2,209 (45.7)	2,629 (54.3)	
	<b>Over 65</b>	167 (45.6 )	199 (54.4)	
<b>Sex</b>	<b>Female</b>	1,576 (50.9)	1,522 (49.1)	<b>0.001</b>
	<b>Male</b>	1,507 (46.3)	1,746 (53.7)	
<b>Quintiles of deprivation in PCT (n=6,259)</b>	<b>Most deprived1</b>	741 (50.2)	736 (49.8)	0.139
	<b>2</b>	657 (49.8)	661 (50.2)	
	<b>3</b>	684 (48.4)	730 (51.6)	
	<b>4</b>	600 (45.7)	714 (54.3)	
	<b>Least deprived 5</b>	353 (48.0)	383 (52.0)	
<b>Smoking cessation signposting (n=3436)</b>	<b>No</b>	1304 (46.5)	1499 (53.5)	<b>0.001</b>
	<b>Yes</b>	211(33.3)	422 (66.7)	

Note:

1. UPDA data include SPCD data from 2008/09 and 2009/10
2. n=6,351 unless otherwise stated
3. Statistically significant differences  $p < 0.05$  in bold:\* n-6,351 unless otherwise stated.

#### 6.4.1.1 Age and tooth restorations

**Table 6-4** results showed that patients who were under the age of 18 years had a significantly lower proportion of tooth restorations (38.4%) compared with working age adults 18-64 years (54.3%) and patients aged over 65 years (54.4%);  $p=0.001$ . Further exploration of this relationship involved the analysis of the rate of tooth restoration within 11 age groups. The results indicated that 55-64 year olds had the highest rate of tooth restoration (66%), followed by the 45-54 year olds (63%) and 65-74 year olds (61.6%) as shown in Figure 6-2 below.



**Figure 6-2: Proportion of patients who had a tooth restoration in the four-years by age band**



#### **6.4.1.2 Sex and tooth restorations**

UPDA data presented in Table 6-4, suggested that a significantly higher proportion of males had received at least one tooth restoration in the four-years when compared with females ( $p=0.001$ ). The proportion of males who had received a restoration at least once in the four-years was 53.7% and females was 49.1% ( $p=0.001$ ),

#### **6.4.1.3 Smoking status and tooth restorations**

A comparison of smokers and non-smokers, which was undertaken using the variable smoking cessation signposting, indicated that a higher proportion of those identified as smokers (66.7%), received a restoration on at least one occasion in the four-year study period, compared with non-smokers (53.4%);  $p=0.001$  (Table 6-4).

When, patients under the age of 18 years were excluded, this analysis confirmed the relationship between smoking and a higher rate of tooth restoration, as adult smokers (those who were signposted to smoking cessation) had a higher rate of tooth restoration (67.6%) compared with those identified as adult non-smokers (non-signposted) (56.7%);  $p= 0.001$ .

### 6.4.2 Instruction/ Advice

This was the most frequently occurring care activity and the second most prevalent in patients, with 49.2% of patients having received instruction/ advice at least once in the four-year study period. Statistically significant differences in the rate of occurrence of instruction/advice by quintile of deprivation, age, adult payment exemption status and smoking status were revealed. The details are shown in **Table 6-5**.

**Table 6-5 Group difference in proportion of patients who had received Instruction/ Advice in between 2008/09 and 2011/12 academic years**

Instruction/ Advice		No Instruction/ Advice N (%)	Instruction/ Advice N (%)	P value
Overall	<b>Overall</b>	3,224 (50.8)	3,127(49.2)	
Adult payment status(n= 5,185)	<b>Exempt</b>	682 (67.9)	283 (32.1)	<b>0.01</b>
	<b>Non-exempt</b>	2,078 (49.7)	2,102(50.3)	
Age groups	<b>Under 18</b>	468 (40.8)	679(59.2)	<b>0.001</b>
	<b>18-64 years</b>	2,597 (54.1)	2,201 (45.9)	
	<b>Over 65</b>	159 (39.2 )	247 (60.8)	
Sex	<b>Female</b>	1,584 (51.1)	1,514 (48.9)	0.293
	<b>Male</b>	1,640 (50.4)	1,613 (49.6)	
Quintiles of deprivation in PCT (n=6,259)	<b>Most deprived 1</b>	796 (53.9)	681 (46.1)	<b>0.003</b>
	<b>2</b>	676 (51.3)	642 (48.7)	
	<b>3</b>	721 (51.0)	693 (49.0)	
	<b>4</b>	631 (48.0)	683 (52.0)	
	<b>Least deprived 5</b>	339 (46.1)	397 (53.9)	
Smoking cessation signposting (n=3436)	<b>No</b>	716 (25.5)	2,087 (74.5)	<b>0.001</b>
	<b>Yes</b>	778 (33.3)	2,658 (66.7)	

Note:

1. UPDA data include SPCD data from 2008/09 and 2009/10

2. n=6,351 unless otherwise stated

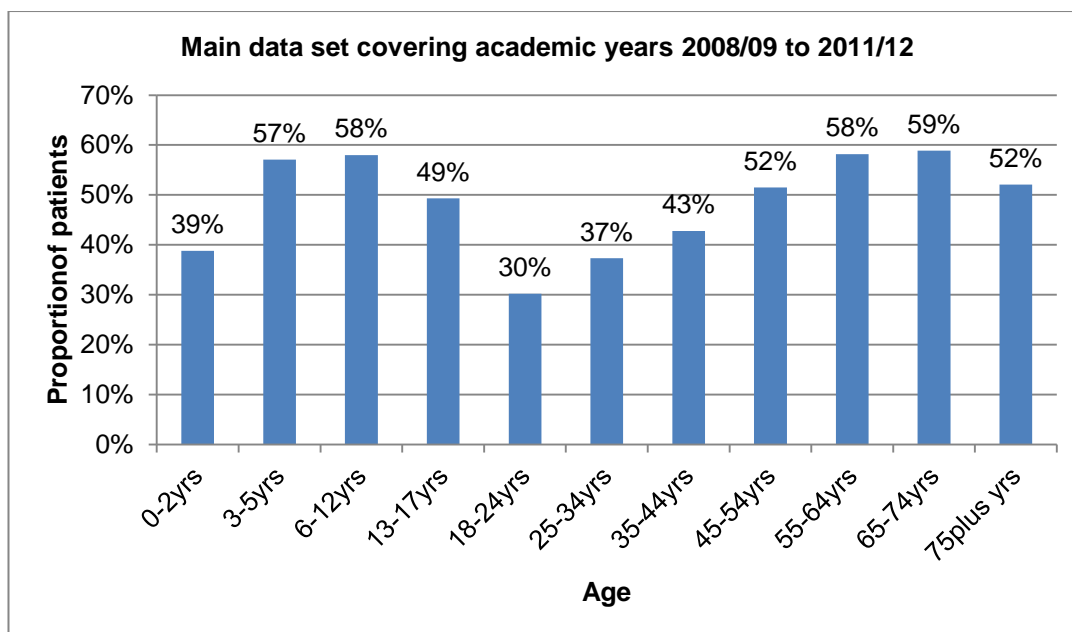
3. Statistically significant differences p<0.05 in bold:\* n-6,351 unless otherwise stated

#### 6.4.2.1 Adult payment exemption and Instruction/Advice

A significantly lower proportion of adults who were entitled to free treatment received Instruction/Advice in the four-years, compared with non-exempt adults (32.1% cf 50.3; p=0.001).

#### 6.4.2.2 Age and Instruction/advice

**Table 6-5** shows that older adults and those aged under 18 years had an almost similar rate of instruction advice. With 60.8% of over 65 year olds having received instruction/advice at least once in the four-year period, whilst 59.2% of children (under 18 years) receiving it. Only 45.9 % of 18-64 year old patients received instruction/advice; this is less than the overall average of 49.2%. Below is a breakdown of the proportion of patients by 11 age bands who received instruction/advice.

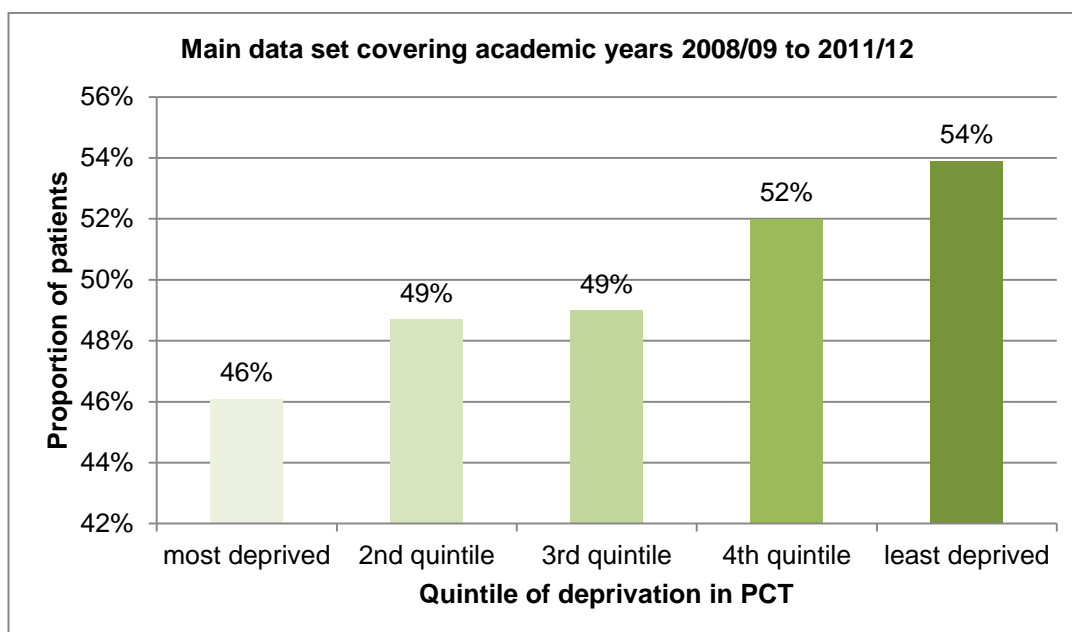


**Figure 6-3 Proportion of patients in each age group who had received Instruction/Advice at least once in the four-year period**

**Figure 6-3** shows that instruction advice seems to be highest at two peaks: 6-12 years of age (58%), and 65-74 years of age (59%). Working age adults have lower rates of receiving Instruction/Advice with 18-24 year old patients having the lowest rate (30%).

#### 6.4.2.3 Quintiles of deprivation in PCT and Instruction/Advice

According to **Table 6-5** the least deprived patients in the PCT had the highest proportion of patients who had received instruction advice at least once in the study period (53.9%). There is a gradient associated with the findings as the most deprived have the lowest proportion of patients who had received instruction/advice (46.1%).



**Figure 6-4 Proportion of patients who received Instruction/advice by Quintile of deprivation in PCT**

#### **6.4.2.4 Smoking status and Instruction/Advice**

From **Table 6-5** a higher proportion of smokers (74.5%) received instruction/advice compared with non-smokers (66.7%). This is higher than the overall average for both, due to uniqueness of the smoker vs non-smokers sample, who represent patients who were seen at least once in the period after team training begun.

### 6.4.3 Scale and polish

Scale and polish is a procedure that was provided at least once to 38.7% of the patients in this study. **Table 6-3** shows statistically significant differences in the rate of scale/polish occurrence by patients' quintile of deprivation, age, adult payment exemption status and smoking status.

**Table 6-6 Group differences in proportion of patients who had received a scale/polish between 2008/09 and 2011/12 academic years**

Scaling and Polishing		No Scale and Polish N (%)	Scale and Polish N (%)	P value
<b>Overall</b>	<b>Overall</b>	3,890 (61.3)	2,461(38.7)	
<b>Adult payment status(n=5,185)</b>	<b>Exempt</b>	662 (65.9)	343 (34.1)	<b>0.001</b>
	<b>Non-exempt</b>	2,199 (52.6)	1,981 (47.4)	
<b>Age groups</b>	<b>Under 18</b>	1,028 (89.6)	119 (10.4)	<b>0.001</b>
	<b>18-64 years</b>	2,717 (56.2)	2,121 (43.8)	
	<b>Over 65</b>	145 (39.6)	221 (60.4)	
<b>Sex</b>	<b>Female</b>	2,390 (77.1)	708 (22.9)	0.398
	<b>Male</b>	1,998 (61.4)	1,255 (38.6)	
<b>Quintiles of deprivation in PCT (n=6,259)</b>	<b>Most deprived 1</b>	1,027 (69.5)	450 (30.5)	<b>0.001</b>
	<b>2</b>	775 (58.8)	543 (41.2)	
	<b>3</b>	841 (59.5)	573 (40.5)	
	<b>4</b>	792 (60.3)	522 (39.7)	
	<b>Least deprived 5</b>	388 (52.7)	348 (47.3)	
<b>Smoking cessation signposting (n=3436)</b>	<b>No</b>	1,466(52.3)	1337 (47.7)	<b>0.001</b>
	<b>Yes</b>	201 (31.8)	432 (68.2)	

Note:

1. UPDA data include SPCD data from 2008/09 and 2009/10

2. n=6,351 unless otherwise stated

3. Statistically significant differences  $p < 0.05$  in bold:\* n-6,351 unless otherwise stated

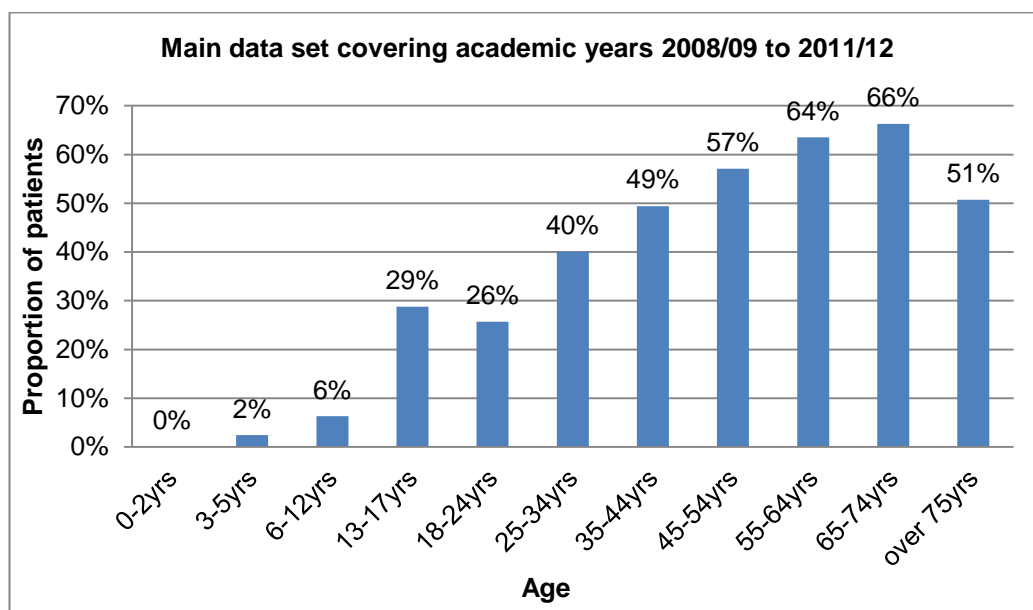
#### 6.4.3.1 Adult payment exempt and scale/polish

Payment status is frequently considered a marker of deprivation, and these results suggest that a significantly higher proportion of non-exempt patients were shown to have had a scale/polish (47%) compared with exempt (34%);  $p = 0.001$ .

#### 6.4.3.2 Age and scale/ polish

The results presented in .

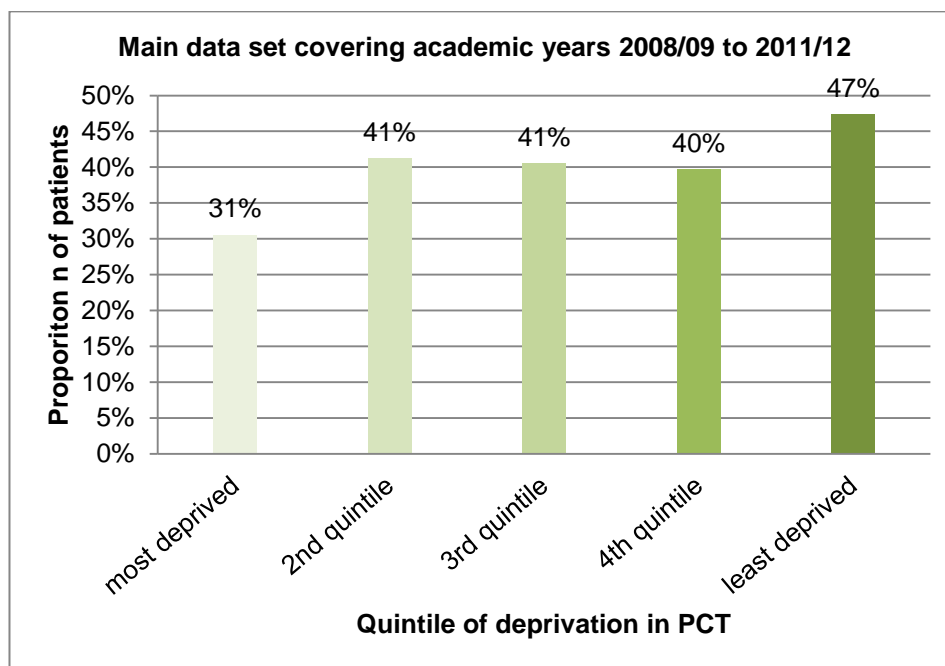
**Table 6-6** suggest that the proportion of patients at UPDA who received a scale/polish is significantly different within age groups. **Figure 6-5** shows that there is a variation in the proportion within the 11 year age groupings, with the older age groups receiving more scaling in the four-year period.



**Figure 6-5 Proportion of patients who had received a scale and polish in four years by age band**

#### 6.4.3.3 Quintiles of deprivation and scale/polish

From **Table 6-6** the patients from the least deprived areas had a significantly higher proportion of patients who had a scale/polish, than those who were from the more deprived quintiles of the patient population. **Figure 6-6** shows the differences in proportions of those who received scaling by quintile of deprivation in PCT.



**Figure 6-6 Proportion of patients who had scale and polish by deprivation quintile**

#### 6.4.3.4 Smoking status and scale/ polish

**Table 6-6** shows that smokers had a significantly higher number of treatment plans that included a scale and polish (68%), compared with non-smokers (47.7%). If children are excluded from the analysis, the results are that 56.5% of adult non-smokers were scaled/polished, compared with 68.5% adult smokers; thus, maintaining the association that more smokers had received a scale/polish within the period;  $p=0.001$ .

#### 6.4.4 Periodontology: Non-Surgical

Periodontology: non-surgical treatments refer to maintenance visits, gingivitis review and root curettage, but do not include scale and polish. The periodontology: non-surgical procedures were provided at least once for 35.3% of the study population within the study period of four-years and there were significant differences in the proportions by adult payment status, age, deprivation and smoking status.

**Table 6-7 Group difference in proportion of patients who had received a treatment for periodontal treatment between 2008/09 and 2011/12 academic years**

Periodontology: non-surgical		No Periodontology: Non-surgical N (%)	Periodontology: Non-surgical N (%)	P value
	<b>Overall</b>	4,303(67.8)	2,048 (32.2)	
<b>Adult Payment status (n= 5,185)</b>	<b>Exempt</b>	655 (65.2)	350 (34.8)	<b>0.02</b>
	<b>Non-exempt</b>	2,578 (61.7)	1,602 (38.3)	
<b>Age groups</b>	<b>Under 18</b>	1,053 (91.8)	94 (8.2)	<b>0.001</b>
	<b>18-64 years</b>	3,064 (63.3)	1,774(36.7)	
	<b>Over 65</b>	186 (50.8)	180 (49.2)	
<b>Sex</b>	<b>Female</b>	2,084 (67.3)	1,014 (32.7)	0.218
	<b>Male</b>	2,219 (68.2)	1,034 (31.8)	
<b>Quintiles of deprivation in PCT (n=6,259)</b>	<b>Most deprived 1</b>	1,067(72.2)	4,10(27.8)	<b>0.001</b>
	<b>2</b>	881 (66.8)	437 (33.20)	
	<b>3</b>	947(67)	467 (33)	
	<b>4</b>	885 (67.4)	429 (32.6)	
	<b>Least deprived 5</b>	453 (61.5)	283 (38.5)	
<b>Smoking cessation signposting (n=3,436)</b>	<b>No</b>	1,909 (68.1)	894(31.9)	<b>0.001</b>
	<b>Yes</b>	325 (51.3)	308 (48.7)	

Note:

1. UPDA data include SPCD data from 2008/09 and 2009/10

2. n=6,351 unless otherwise stated

3. Statistically significant differences p<0.05 in bold:\* n=6,351 unless otherwise stated

##### 6.4.4.1 Age and periodontology: non-surgical procedures

The over 65 years age group had the highest proportion of patients who had received periodontology: non-surgical procedures (49%), compared with (36.7%) of the 18-64 years and (8.2%) of the under 18 years.

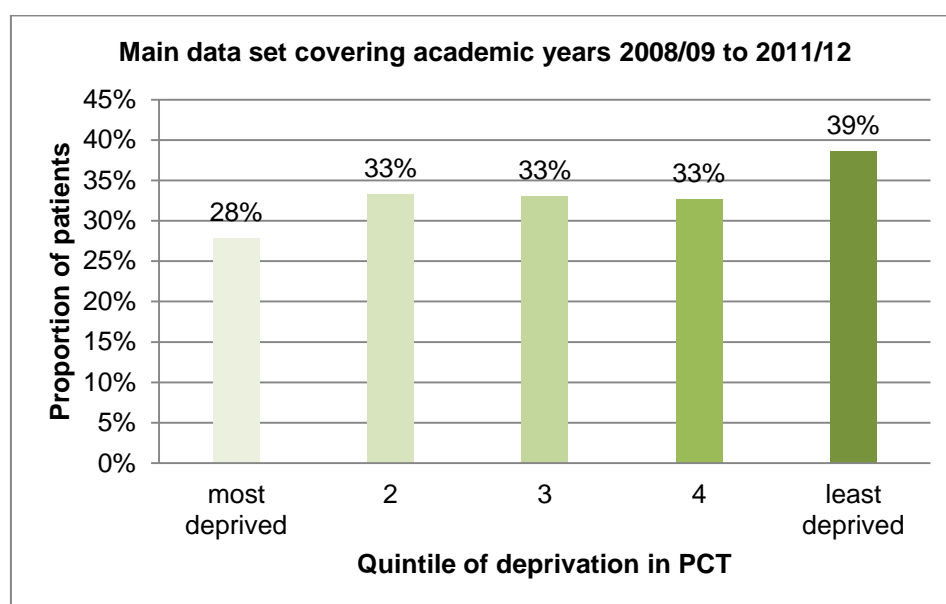


#### 6.4.4.2 Adult payment exemption status and periodontology: non-surgical procedures

There was a significantly higher proportion of non-exempt patients who had received a non-surgical treatment (38.3%) compared with those with exempt payment status 34.8%; $p=0.02$

#### 6.4.4.3 Quintiles of deprivation and periodontology: non-surgical procedures

There was a statistically significant 'gradient-type' pattern, between the proportions of patients who had received a treatment referred to as periodontology: non-surgical procedures (gum treatments that did not include scale and polish), and quintiles of deprivation based on the patients' residence. Those who were most deprived had the lowest proportion of periodontology: non-surgical procedures as shown in **Figure 6-7** below.



**Figure 6-7 Proportion of patients who received periodontology non-surgical procedures by deprivation quintile**

### 6.4.5 Tooth extractions

Tooth extractions are commonly considered undesirable as a first-line treatment option; however, they remain an important component of patient management when a tooth cannot be restored. The following are the results that describe the association between patients' socio-demography and having had at least one extraction in UPDA between the academic years 2008/09 and 2011/12. Overall, 25% of the patients had at least once extraction in the 4-year treatment period. This included children who could have received an extraction during exfoliation of primary dentition. The results in **Table 6-8** suggest that there is a significant difference in the proportion of patients who had tooth extractions within age groups, sex, adult payment status, quintiles of deprivation and smoking status (smoking sign-posted individuals).

**Table 6-8 Group differences in the proportion of patients who had received a tooth extraction between 2008/09 and 2011/12 academic years**

Tooth extractions		No extractions N (%)	Tooth extractions N (%)	P value
	<b>Overall</b>	4754 (74.9)	1597 (25.1)	
<b>Adult Payment status (n= 5,185)</b>	<b>Exempt</b>	622 (61.9))	383 (38.1)	<b>0.001</b>
	<b>Non-exempt</b>	3,115 (74.5)	1,065(25.5)	
<b>Age groups</b>	<b>Under 18</b>	1,002 (87.4))	145 (12.6)	<b>0.001</b>
	<b>18-64 years</b>	3,538 (73.1)	1,300 (26.9)	
	<b>Over 65</b>	214 (58.5)	152 (41.5)	
<b>Sex</b>	<b>Female</b>	2,390 (77.1)	708 (22.9)	<b>0.001</b>
	<b>Male</b>	2,364 (72.7)	889 (27.3)	
<b>Quintiles of deprivation in PCT(n=6,259)</b>	<b>Most deprived1</b>	1,028 (69.6)	449 (30.4)	<b>0.001</b>
	<b>2</b>	982 (74.5)	336 (25.5)	
	<b>3</b>	1,086 (76.8)	328 (23.2)	
	<b>4</b>	1,014 (77.2)	300 (22.8)	
	<b>Least deprived 5</b>	571 (77.6)	165 (22.4)	
<b>Smoking cessation signposting (n=3,436)</b>	<b>No</b>	2,176 (77.6)	627 (22.4)	<b>0.001</b>
	<b>Yes</b>	382 (60.3)	251 (39.7)	

Note:

1. UPDA data include SPCD data from 2008/09 and 2009/10

2. n=6,351 unless otherwise stated

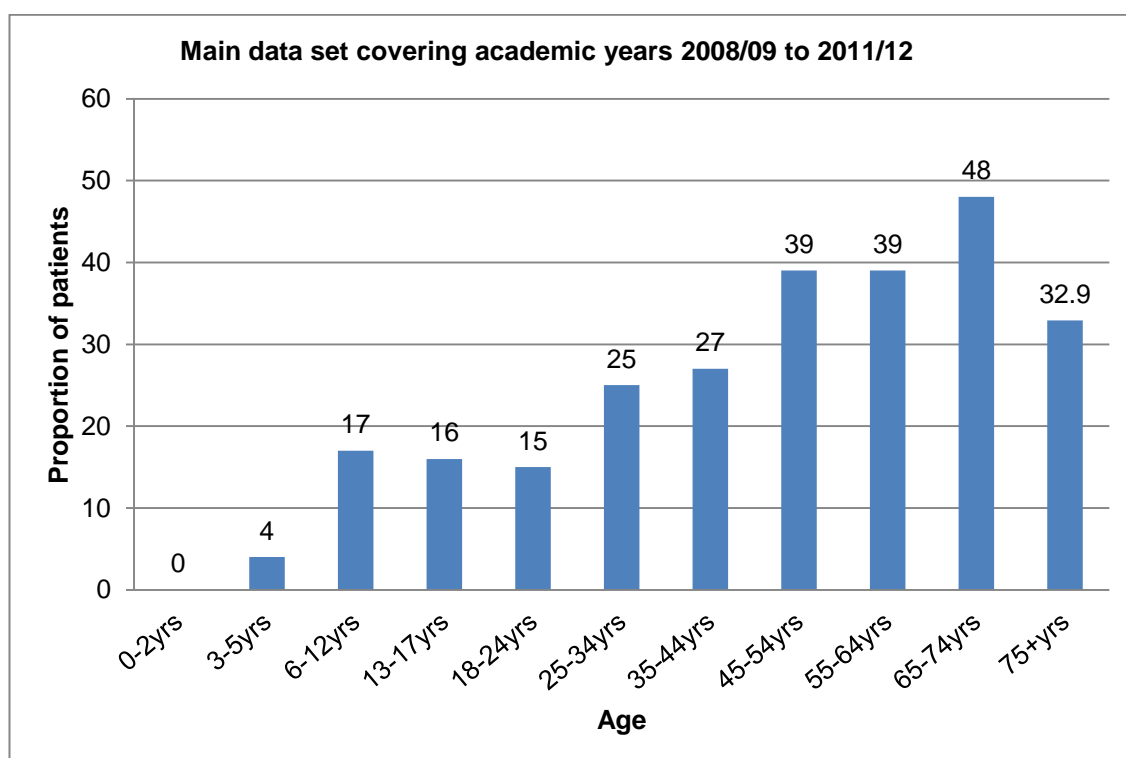
3. Statistically significant differences  $p < 0.05$  in bold.\* n=6,351 unless otherwise stated

#### 6.4.5.1 Adult payment status and tooth extractions

The proportion of patients who had tooth extractions amongst payment exempt adult patients is (38%). This is significantly lower than the proportion among non-exempt adult patients (25%) ( $p=0.001$ ).

#### 6.4.5.2 Age and tooth extractions

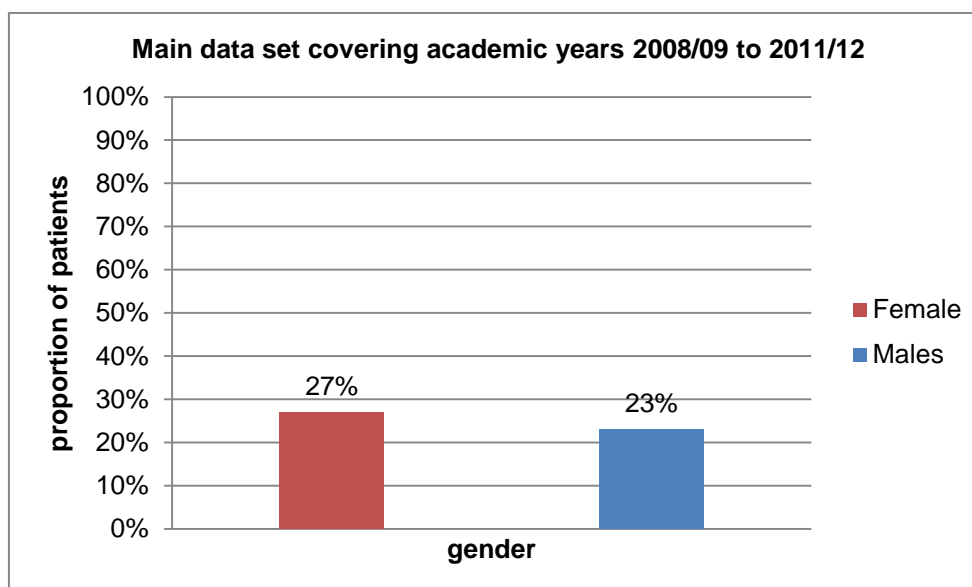
Patients under the age of 18 years had a significantly lower proportion receiving at least one extraction (12.6%), compared with 18-64 year olds (26.9%) and over 65 years (41.5%). Further analysis of the distribution of extraction within eleven age groups (**Figure 6-8**) indicated that older age groups had higher proportions of extraction recipients, with a peak in the 65-74 year age-band.



**Figure 6-8 Proportion of patients who had tooth extractions by age**

#### 6.4.5.3 Sex and tooth extractions

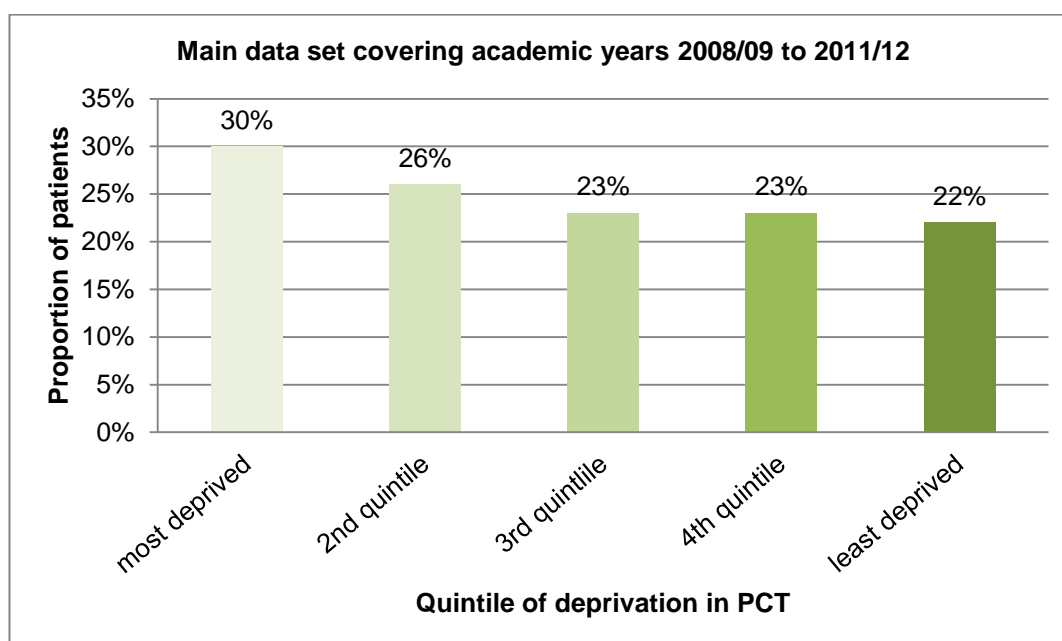
There were significant differences in the rate of extraction by sex. A higher proportion of male patients had at least one extraction in the four-years, compared with females (27.3% cf 22.9%;  $p=0.001$ ).



**Figure 6-9 Proportion of female and male patients who had received an extraction**

#### 6.4.5.4 Deprivations and tooth extractions

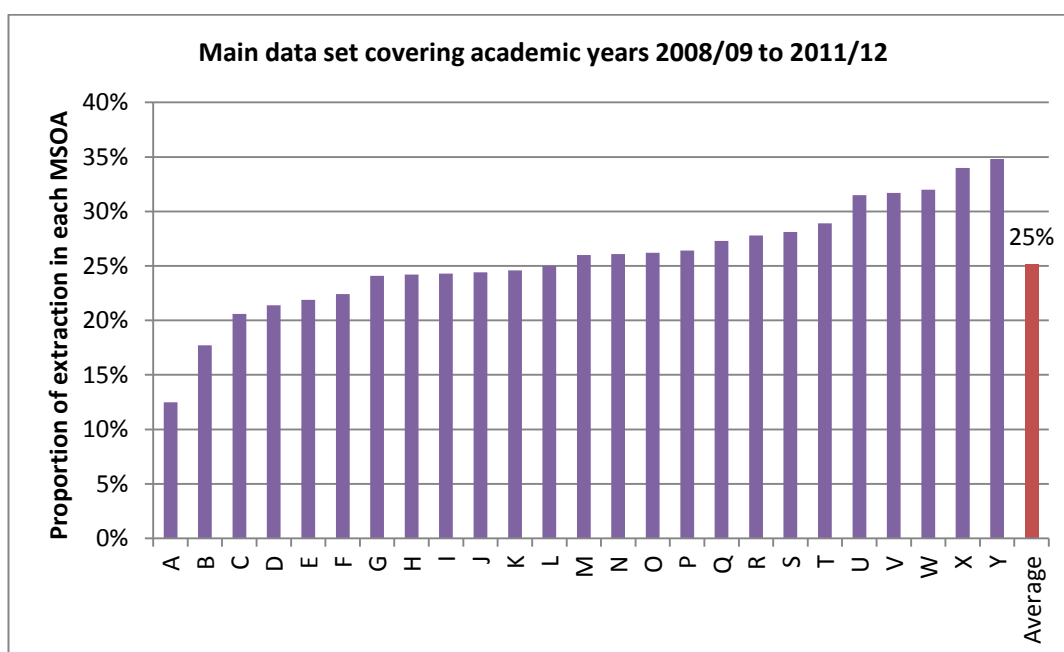
When quintiles of deprivation were investigated to ascertain the distribution of extractions, the results suggested that the most deprived had a higher proportion of tooth extractions than the least deprived **Figure 6-10**.



**Figure 6-10 Proportion of patients who received a tooth extraction at least once in four years by deprivation quintile**

#### 6.4.5.5 Tooth extractions and geography

Following the observation of the differences in the quintiles of deprivation and the proportion of extraction, an analysis of rate of extraction in middle layer super output areas (MSOA) was undertaken. MSOA is a census region with a minimum population of 5000 and a maximum of 15,000. The proportion of tooth extractions varied significantly ( $p=0.001$ ) between the 25 different MSOAs in (the patient population for this set of analysis was 4,885) **Figure 6-11**.



\*the patient population for this set of analysis was 4,885 limited to only patients who came from Portsmouth ; the MSOA names have been replaced with alphabetical letters to maintain anonymity

**Figure 6-11 Proportion of patients from those treated at UPDA from Portsmouth City who had tooth extractions by MSOAs (Middle Layer Super Output Area)**

#### 6.4.5.6 Smoker signposting and tooth extractions

There is a significant difference between the proportion of tooth extractions among smokers (who were signposted to smoking cessation) and non-smokers. This relationship is sustained even when children are excluded from the analysis. Forty per cent of adult smokers had a tooth extraction compared with 24% of adult non-smokers ( $p=0.001$ ).

#### 6.4.6 Fissure sealants

There were 829 patients out of 6,351 who had at least one fissure sealant in the Academy in Portsmouth, between 2008/09 and 2011/12 academic years. This translates to 13.1% of the study population. Age and adult payment status showed statistically significant associations with those having received of fissure sealants. These results are described detail in **Table 6-9** which shows the group differences in those having received fissure sealants.

**Table 6-9 Group differences in the proportion of patients who had received fissure sealants between 2008/09 and 2011/12 academic years**

Fissure sealants		No fissure sealants N (%)	Fissure sealants N (%)	P=value
	<b>Overall</b>	5,522 (86.9)	829 (13.1)	
<b>Adult payment Status (n= 5,185)</b>	<b>Non-exempt</b>	3,804 (91.5)	352 (8.5)	<b>0.02</b>
	<b>Exempt</b>	941(93.6)	64 (6.4)	
<b>Age groups</b>	<b>Under 18</b>	739 (64.4)	408 (35.6)	<b>0.001</b>
	<b>18-64 years</b>	4,419 (91.3)	419 (8.7)	
	<b>Over 65</b>	364 (99.5)	2 (0.5)	
<b>Sex</b>	<b>Female</b>	2,708 (87.4)	390 (12.6)	0.297
	<b>Male</b>	2,814 (87.4)	439 (13.5)	
<b>Quintiles of deprivation (in PCT) n=6,259</b>	<b>Most deprived1</b>	1,274 (86.3)	203 (13.7)	0.689
	<b>2</b>	1,147 (87)	171 (13.0)	
	<b>3</b>	1245 (88)	169 (12)	
	<b>4</b>	1,141 (86.8)	173(13.2)	
	<b>Least deprived 5</b>	637 (86.5)	99 (13.5)	
<b>Smoking cessation signposting (n=3,436)</b>	<b>No</b>	2,055 (92.3)	172 (7.7)	0.688
	<b>Yes</b>	570 (91.8)	51 (8.2)	

Note:

1. UPDA data include SPCD data from 2008/09 and 2009/10

2. n=6,351 unless otherwise stated

3. Statistically significant differences  $p < 0.05$  in bold.\* n=6,351 unless otherwise stated

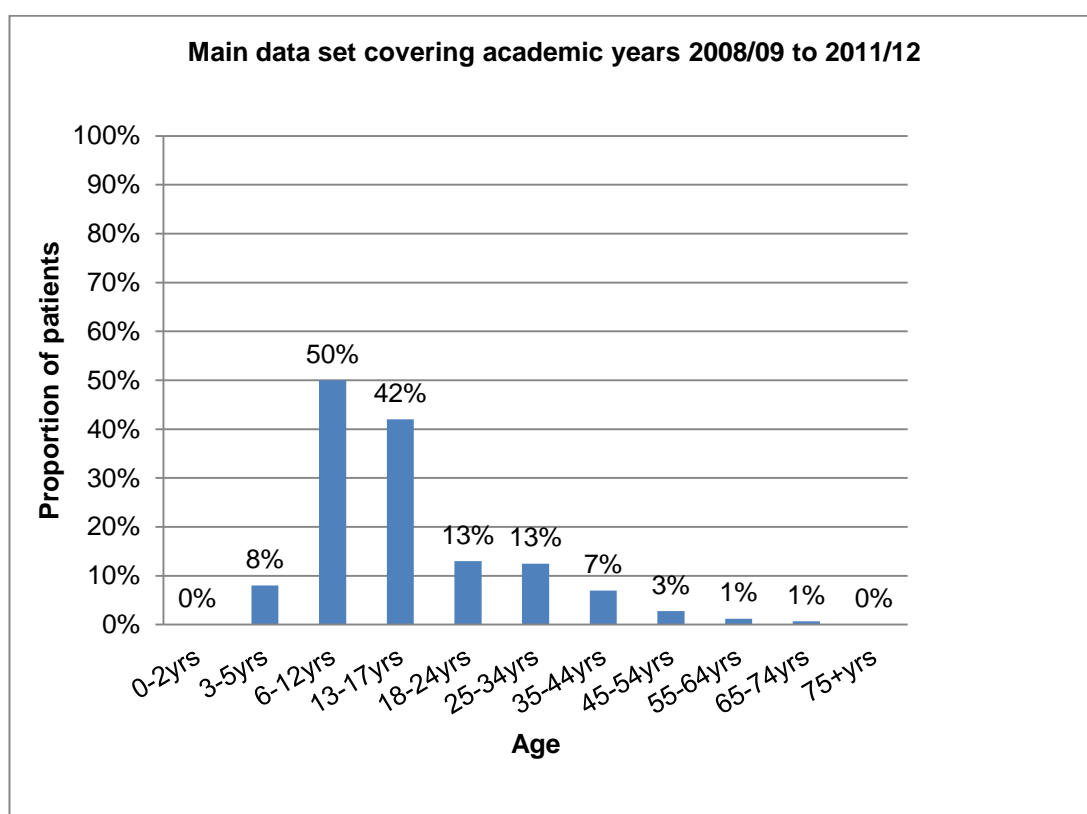
##### 6.4.6.1 Adult payment exemption among adults and fissure sealants

**Table 6-9** indicated that there is a significant difference ( $p=0.02$ ) in the proportion of fissure sealant treatments in the different payment status groups. Adults who were exempt from

payment had a lower proportion of fissure sealant cases (6.4%), compared with non-exempt adult patients (8.5%).

#### 6.4.6.2 Age and fissure sealant

A higher proportion of patients under the age of 18 had received fissure sealants (35.6%) compared with working adults (8.7%) and over 65 year olds (0.9%) ( $p = 0.001$ ). A more detailed description of the variation in the proportion of patients who had received fissure sealants in eleven age groups is shown in **Figure 6-12**.



**Figure 6-12 Proportion of fissure sealants by age**

The graph **Figure 6-12** shows that the 6-12 year olds had the highest proportion of patients who had received a fissure sealant at least once in the four-year study period.

### 6.4.7 Endodontics

Endodontic procedures (procedures that involved root canal treatment, whether in children or adults), were analysed for any association to socio-demography of the patients. Overall 6.6% of patients had an endodontic procedure at least once in the four-years.

**Table 6-10** shows the results, which suggest that age and smoking status have a statistically significant association with having received endodontic treatment at least once in the four academic years studied.

**Table 6-10 Group differences in the proportion of patients who had received an endodontic treatment in four years**

Endodontic		No endodontics N (%)	Endodontics N (%)	P=value
	<b>Overall</b>	93.40%	6.6%	
<b>Adult payment status (n=5,185)</b>	<b>Non-exempt</b>	3,885 (92.2)	325 (7.8)	
	<b>Exempt</b>	922 (91.7)	83 (8.3)	0.609
<b>Age groups</b>	<b>Under 18</b>	1,137 (99.1)	10 (0.9)	<b>0.001*</b>
	<b>18-64 years</b>	4,457 (92.1)	381 (7.9)	
	<b>Over 65</b>	337 (92.1)	29 (7.9)	
<b>Sex</b>	<b>Female</b>	2,901 (93.6)	197 (6.4)	0.426
	<b>Male</b>	3,030 (93.1)	223 (6.9)	
<b>Quintiles of deprivation in PCT (n=6,259)</b>	<b>Most deprived1</b>	1,393 (94.3)	84 (5.7)	0.526
	<b>2</b>	1,228 (93.2)	90 (6.8)	
	<b>3</b>	1315 (93)	99 (7.0)	
	<b>4</b>	1,224 (93.2)	90 (6.8)	
	<b>Least deprived</b>	682 (92.7)	54 (7.3)	
	<b>5</b>			
<b>Smoking cessation signposting (n=3,436)</b>	<b>No</b>	2,595 (92.6)	208 (7.4)	<b>0.001*</b>
	<b>Yes</b>	557 (88)	76 (12)	

Note:

1. UPDA data include SPCD data from 2008/09 and 2009/10

2. n=6,351 unless otherwise stated

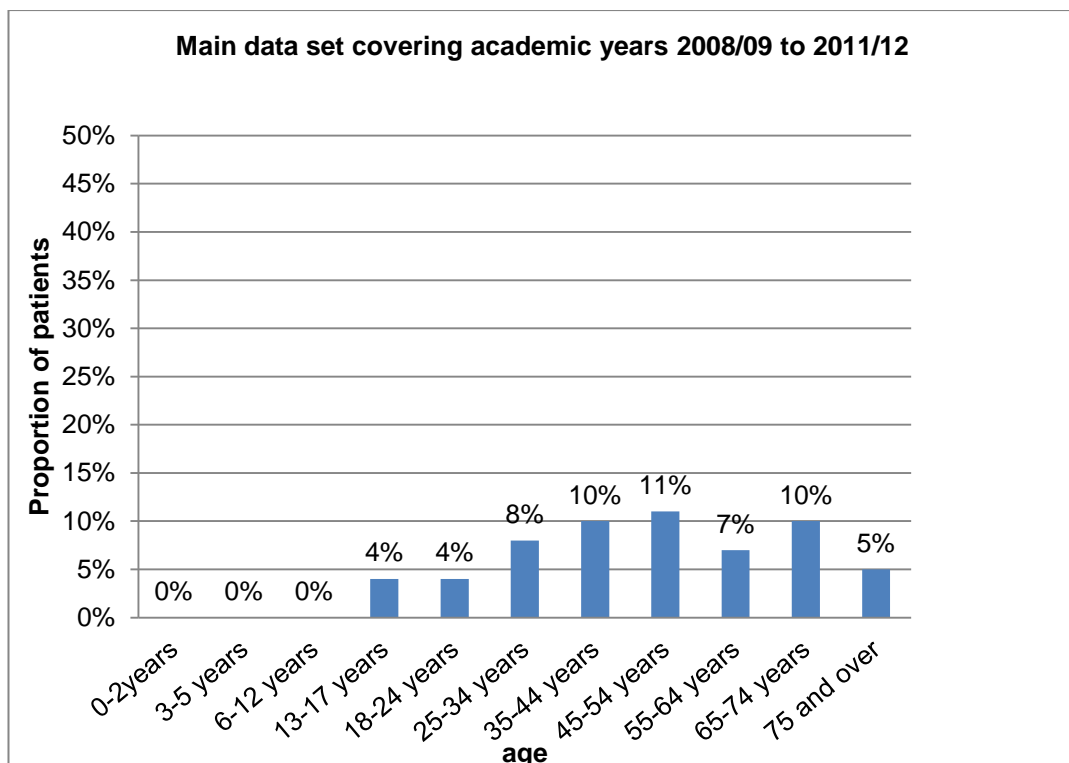
3. Statistically significant differences  $p < 0.05$  in bold.\* n=6,351 unless otherwise stated



#### 6.4.7.1 Age and endodontic treatment

Working aged adults (18-64 year olds) had a similar proportion of endodontic procedures as over 65 year olds (both at 7.9%). Those under 18 years of age had received a significantly lower proportion of endodontic treatments (1%);  $p=0.001$ .

A more detailed analysis of the relationship between age and having had endodontic treatment within 11 age groups (**Figure 6-13**) shows that the highest proportion of patients who had received endodontic procedures was the 45-54 year old age groups (11%), followed closely by the 65-74 year olds (10%), and the 35-44 year olds (10%).



**Figure 6-13 Proportion of patients who received endodontic treatment at least once in the four years**

#### 6.4.7.2 Smoking status and endodontic treatments

The analysis of having received endodontic treatment and having had smoking cessation signposting showed that among smokers there was a higher proportion of patients who had received endodontic treatment (12%); compared with non-smokers (7%);  $p=0.001$ . When children were excluded from the analysis, the relationship persisted with smokers having a higher proportion of patients who had received endodontic treatment (12%) compared with adult non-smokers (9.1%); ( $p=0.0021$ ).

#### 6.4.8 Partial Dentures

Five per cent of the patients in the data set had received at least one partial denture treatment. The results presented in **Table 6-11** indicate that there are statistically significant differences in the proportion of patients who had partial dentures within age groups, adult payment status, quintiles of deprivation and smoking cessation signposting.

**Table 6-11 Group differences in the proportion of patients who had received a partial denture in the four years**

Partial dentures		No partial denture N (%)	Partial denture N (%)	P value
<b>Overall</b>		6,027 (94.9 )	324 (5.1)	
<b>Adult payment status (n= 5,185)</b>	<b>Non-exempt</b>	3,947 (94.4)	233 (5.6)	0.001*
	<b>Exempt</b>	915(91)	90 (9)	
<b>Age groups</b>	<b>Under 18</b>	1147(100)	0 (0)	0.001*
	<b>18-64 years</b>	4,611 (95.3)	227 (4.7)	
	<b>Over 65</b>	269 (73.5)	97 (26.5)	
<b>Sex</b>	<b>Female</b>	2,954 (94.5)	144 (4.6)	0.109
	<b>Male</b>	3,073 (95.4)	180 (5.5)	
<b>Quintiles of deprivation (in PCT) (n=6,259)</b>	<b>Most deprived 1</b>	1,386 (93.8)	91 (6.2)	0.02*
	<b>2</b>	1,248 (94.7)	70 (5.3)	
	<b>3</b>	1,343 (95.0)	71 (5.0)	
	<b>4</b>	1,269 (96.6)	45 (3.4)	
	<b>Least deprived 5</b>	692 (94.0)	44 (6)	
<b>Smoking cessation signposting (n=3,436)</b>	<b>No</b>	2,661 (94.9)	142 (5.1)	0.001*
	<b>Yes</b>	545 (86.1)	88 (13.9)	

Note:

1. UPDA data include SPCD data from 2008/09 and 2009/10

2. n=6,351 unless otherwise stated

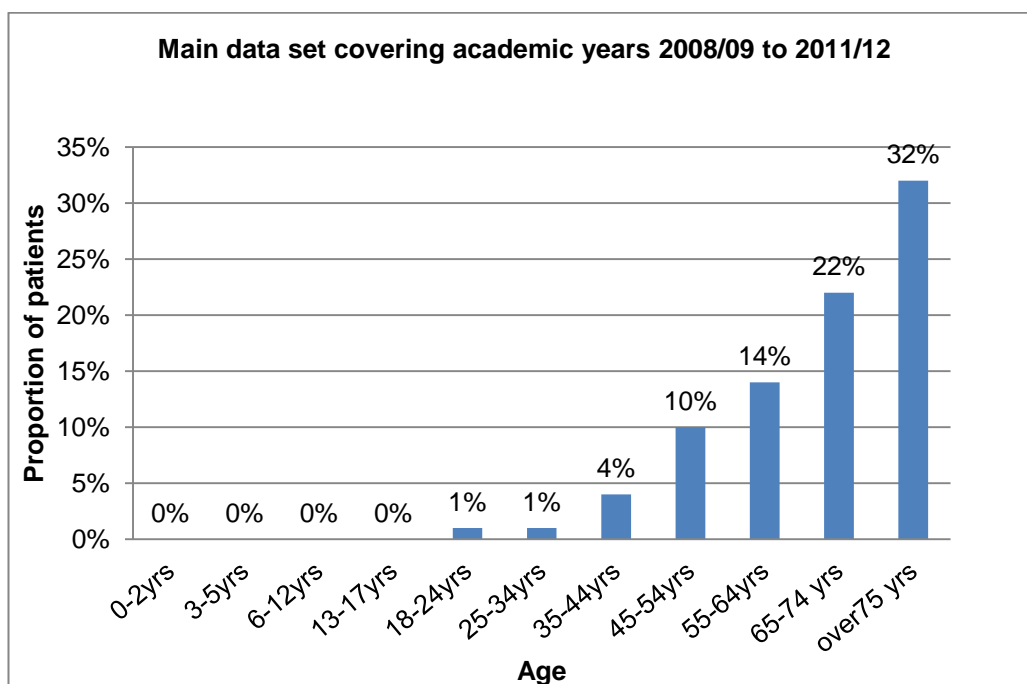
3. Statistically significant differences  $p < 0.05$  in bold:\* n=6,351 unless otherwise stated

#### 6.4.9 Adult Payment status and partial dentures

The adult patients who were exempt from payment had a significantly higher proportion of patients who had received partial denture treatments (9%), compared with the non-exempt adult patients (5.6%);  $p=0.001$ .

#### 6.4.9.1 Age and partial dentures

Patients under the age of 18 had no partial dentures, whilst 24% of working age adults and 27% over 65 year old adults had received at least one partial denture treatment ( $p=0.001$ ). **Figure 6-14** shows the eleven year age groups and the proportions of patients within each age group who had a partial denture. The 75+ year olds were the largest number patients who had a treatment plan that involved a partial denture.



**Figure 6-14 Proportion of patients who had received a partial denture at least once in the four years by age band**

#### 6.4.9.2 Quintiles of deprivation and partial dentures

Patients from the most deprived quintiles and the least deprived quintile had the highest proportion of patients who had received partial dentures; both 6%. Those in the 3<sup>rd</sup> quintile had the lowest proportion (3.4%);  $p=0.02$ .

#### 6.4.9.3 Smoking status and partial dentures

Smokers (patients who had been signposted to smoking cessation) had a significantly higher proportion of partial dentures (13.9%) than non-smokers (patients who had not been signposted) (5.1%). This relationship remains statistically significant when children were excluded from the analysis: non-smokers (5.9%) compared with smokers (12.7%);  $p=0.001$ .

#### 6.4.10 Crowns-porcelain bonded

Overall 2.8% of the patients had received at least one crown treatment in the four-years.

**Table 6-12 Group difference in proportion of patients who had received a crown treatment in the four years**

<b>Crown porcelain bonded</b>		<b>No crown N (%)</b>	<b>Crown N (%)</b>	<b>P value</b>
<b>Overall</b>		6,171 (97.2)	180 (2.8)	
<b>Adult payment status(n= 5,185)</b>	<b>Exempt</b>	972(96.7)	33 (3.3)	0.104
	<b>Non-exempt</b>	4,033 (96.5)	147 (3.5)	
<b>Age groups</b>	<b>Under 18</b>	1,147 (100)	0 (0)	<b>0.001*</b>
	<b>18-64 years</b>	4,670 (96.5)	168 (3.5)	
	<b>Over 65</b>	354 (96.7)	12 (3.3)	
<b>Sex</b>	<b>Female</b>	3,003 (96.9)	95 (3.1)	0.276
	<b>Male</b>	3,168 (97.4)	85 (2.6)	
<b>Quintiles of deprivation in PCT(n=6,259)</b>	<b>Most deprived1</b>	1,447 (98)	30 (2)	0.153
	<b>2</b>	1,281(97.2)	37(2.8)	
	<b>3</b>	1,365 (96.5)	49 (3.5)	
	<b>4</b>	1,276 (97.1)	38( 2.9)	
	<b>Least deprived 5</b>	710(96.5)	26 (3.5)	
<b>Smoking cessation signposting (n=3,436)</b>	<b>No</b>	2,707 (96.6)	96 (3.4)	<b>0.001</b>
	<b>Yes</b>	597 (94.3)	36 (5.7)	

Note:

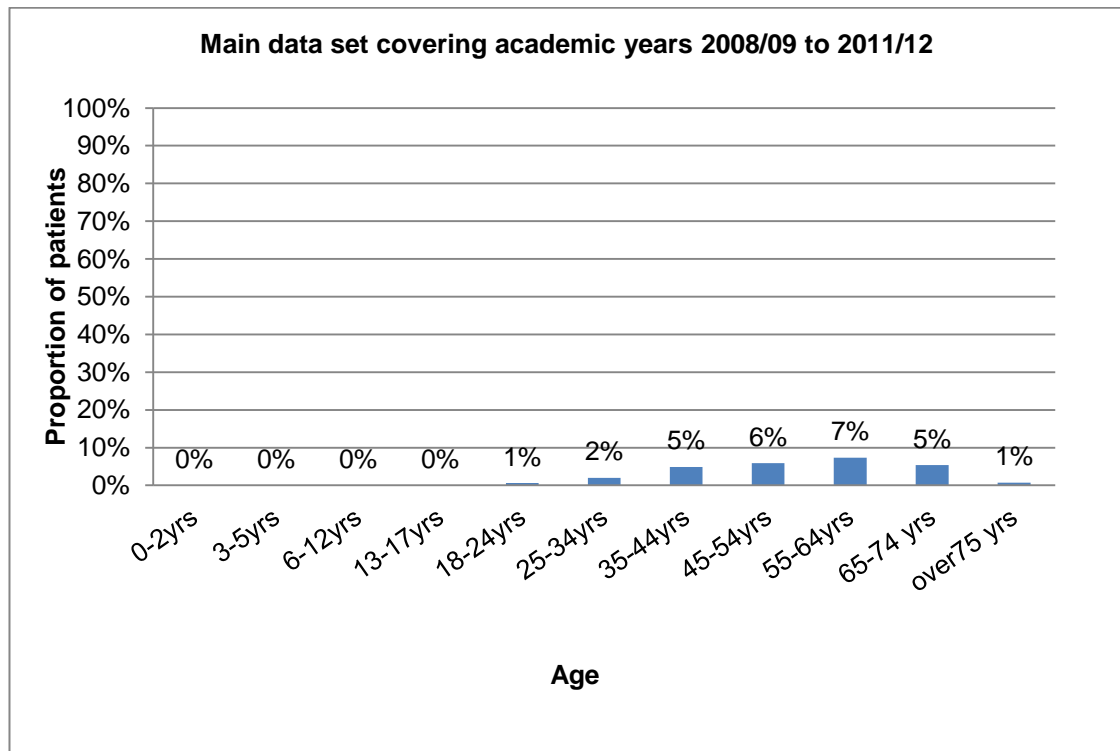
1. UPDA data include SPCD data from 2008/09 and 2009/10

2. n=6,351 unless otherwise stated

3. Statistically significant differences  $p < 0.05$  in bold.\* n=6,351 unless otherwise stated

#### 6.4.10.1 Age and crowns

Significant differences existed in the proportion of patients who had received crowns depending on their age groups. **Figure 6-15** highlights eleven age groups and the proportion of patients who had received a crown in each. From the graph, 55-54 year olds have the highest proportion of patients who had received a crown (7.3%), followed by 45-54 year olds (5.9%) and 65-74 year olds (5.4%).



**Figure 6-15 Proportion of patients who had had crowns by age**

#### 6.4.10.2 Smoking and crowns

While overall **Table 6-12** shows that smokers had a significantly higher proportion of crowns (5.7%) compared with non-smokers (3.4%);  $p=0.001$ , when children were eliminated from the analysis, the difference was found not to be statistically significant.

## **6.5 Multivariate modelling of treatment needs for adults as predicted by individual characteristics and area level characteristics**

### **6.5.1 Introduction**

This section reports on the logistic regression models that were undertaken to ascertain the socio-demographic predictors of treatment need. Five out of the nine treatments analysed in the univariate analysis were used in the multivariate analysis. These treatments were selected because they were high volume treatments and showed strong significant associations with more than two socio-demographic variables in the univariate analysis reported in section 6.4.

The treatments were:

- i. Tooth restorations
- ii. Instruction/Advice
- iii. Partial Dentures
- iv. Tooth extractions
- v. Scale and Polish

### **6.5.2 Patients**

Only adult patients were included in the logistic regression analysis. The number of patients included in the analysis was 2,782. Only patients who had been seen at UPDA at least once in the period after expansion were included, to ensure the description of predictors of care need was based on the full study period.

### **6.5.3 Multivariate logistic regression modelling and validation**

A total of five logistic regression models were undertaken; the effects of each variable was adjusted for within the model. Results are reported in tables that show odds ratios, 95% confidence intervals and p value. Validation of the models' predictive power was shown by the ROC area under the curve [0.5-0.6 weak model; 0.6-0.7 fair model; 0.8-upwards strong model predicting power].

### 6.5.4 Tooth restoration

The logistic regression model in **Figure 6-14** shows that tooth restorations could be predicted by adult payment exemption status, age, quintile of deprivation, sex, and smoking status; while controlling for the effects of each variable. Payment exempt adults were twice more likely to have had a tooth restoration than non-exempt adults and for every year older, a patient was 2% more likely to have a tooth restoration as part of the treatment plan. Females were 20% less likely to have had a tooth restoration in the four-year study period than males ( $p=0.02$ ) and smokers were 57% more likely to have had a tooth restoration as part of a treatment plan than non-smokers ( $p=0.001$ ). Quintile of deprivation which had not shown any predicting effect in the univariate model had an effect in this model, with patients from the most deprived quintile being 1.6 times more likely to receive a tooth restoration than the least deprived ( $p=0.001$ ) and the second most deprived being 1.3 times more likely to receive a tooth restoration than the least deprived ( $p=0.012$ ). Smokers were 1.6 times more likely to have received a tooth restoration than non-smokers. The ROC area under the curve was 0.64 showing the model had fair predicting power.

**Table 6-13 Logistic regression model predicting odds of tooth restoration over academic years 2008/09 to 2011/12**

Outcome	Predictor variable	Odds ratio	95% C.I. for Odds ratio		P value	ROC area under the curve
			Lower	Upper		
Tooth restorations n=2,782	Adult payment exemption	2.108	1.576	2.819	0.01	0.64
	Age	1.02	1.015	1.025	0.01	
	Quintile in PCT(1)	1.655	1.274	2.151	0.01	
	Quintile in PCT(2)	1.376	1.074	1.764	0.012	
	Quintile in PCT(3)	1.145	0.904	1.449	0.262	
	Quintile in PCT(4)	1.086	0.862	1.368	0.483	
	Sex	0.832	0.712	0.971	0.02	
	Smoking status	1.569	1.29	1.909	0.01	

a) Age (continuous); b) smoker (non-smoker ref cat); c) sex (male is ref cat); d) Quintiles of deprivation (Quintiles of deprivation- 5 is the least deprived and is the ref cat); e) non-exempt is ref category f) p value < 0.05 is statistically significant

#### **6.5.4.1 Sex and tooth restorations**

The relationship between sex and tooth restoration was further analysed in order to assess whether there were differences in effect of predictors for males and females individually. The results showed that the effect of adult payment exemption on tooth restorations was higher for males than females when the model was stratified by patients' sex. Therefore adult payment exempt males were four times more likely to have tooth restorations than non-exempt males, whilst exempt females were 1.4 times more likely to have tooth restorations than non-exempt females. The other variables (age, quintiles of deprivation and smoking status) showed similar odds ratios as the model in **Table 6-13** even after stratification.



### 6.5.5 Instruction/Advice

The logistic regression model in **Table 6-14** shows whether an adult patient who received instruction/ advice at least once in the four-year period could be predicted by adult payment status, age, quintile of deprivation in PCT and smoking status. The model shows that adult exempt patients were twice more likely than non-exempt adult patients to receive instruction/advice  $p=0.001$ . Smokers were four times more likely than non-smokers to receive smoking advice  $p=0.001$ . Those who were from the least deprived areas of the quintile in the PCT were more likely to receive instruction advice than those who were more deprived. Sex was not a significant predictor of receiving instruction/advice. This difference was largest between the most deprived and the least deprived. ROC area under the curve was 0.7, showing this is a good model.

**Table 6-14 Logistic regression model predicting odds of receiving instruction/advice over academic years 2008/09 to 2011/12**

Outcome	Predictor variable	Odds ratio	95% C.I.for Odds ratio		P value	ROC area under the curve
			Lower	Upper		
Instruction advice n=2,778	Adult payment exemption	2.198	1.506	3.207	0.001	0.7
	Age	1.038	1.032	1.045	0.001	
	Quintile in PCT(1)	0.371	0.256	0.536	0.001	
	Quintile in PCT(2)	0.48	0.332	0.692	0.001	
	Quintile in PCT(3)	0.54	0.376	0.776	0.001	
	Quintile in PCT(4)	0.608	0.421	0.879	0.009	
	Sex	1.192	0.993	1.43	0.059	
	Smoking status	4.124	3.088	5.508	0.001	

a) Age (continuous); b) smoker (non-smoker ref cat); c) sex (male is ref cat); d) Quintiles of deprivation (Quintiles of deprivation- 5 is the least deprived and is the ref cat); e) non-exempt is ref category f) p value< 0.05 is statistically significant

### 6.5.6 Scale and polish

The model predicting scale/polish at UPDA in the four-year study period suggests that adult payment exemption status, age, smoking status, and quintile of deprivation in the PCT all have a role in the prediction of scale and polish, while controlling for the other variables as shown in **Table 6-13**. The model shows that for every year of age increase there is a 3.7% increased likelihood that patients had received a scale and polish. Exempt adults were 1.7 times more likely to have had at least one scale and polish in the four-years. While smokers were 1.7 times more likely than non-smokers to have received a scale and polish:  $p=0.001$ . Quintile of deprivation in PCT was significant in predicting scale and polish. All associations were significant at  $p=0.001$ . Only the most deprived quintile were significantly less likely to have had a scale and polish (OR 0.5 95% CI. 0.379 to 0.692)  $p=0.0001$  when compared with the least deprived quintile. Sex was not a predictor of receiving a scale and polish. The ROC area under the curve is 0.7 suggesting that the model has fair predicting power.

**Table 6-15 Logistic regression predicting odds of scale/polish over academic years 2008/09 to 2011/12**

Outcome	Predictor variable	Odds ratio	95% C.I.for Odds ratio		P value	ROC area under the curve
Scale/polish N=2,778			Lower	Upper		
	Adult payment exemption	1.745	1.308	2.327	0.001	
	Age	1.037	1.032	1.043	0.001	0.7
	Quintile in PCT(1)	0.512	0.379	0.692	0.001	
	Quintile in PCT(2)	0.754	0.56	1.016	0.063	
	Quintile in PCT(3)	0.72	0.538	0.964	0.027	
	Quintile in PCT(4)	0.818	0.608	1.101	0.185	
	Sex	1.039	0.885	1.219	0.642	
	Smoking status	1.737	1.421	2.124	0.001	

a) Age (continuous); b) smoker (non-smoker ref cat); c) sex (male is ref cat); d) Quintiles of deprivation (Quintiles of deprivation- 5 is the least deprived and is the ref cat); e) non-exempt is ref category f)  $p\text{value} < 0.05$  is statistically significant

### 6.5.7 Tooth extractions multivariate model

The results in **Table 6-16** suggest that deprivation quintile of patients' residence, sex, age and smoking status and exemption status have a role in predicting whether or not a patient has had an extraction in UPDA between 2008/09 and 2011/12 academic years. Results in **Table 6-16**.

**Table 6-16 Logistic regression model predicting tooth extractions**

Outcome	Predictor variable	Odds ratio	95% C.I. for Odds ratio		P value	ROC area under the curve
			Lower	Upper		
Tooth extractions N=2,778	Age	1.033	1.028	1.039	0.001	0.7
	Adult payment exemption	1.815	1.38	2.388	0.001	
	Sex	0.8	0.672	0.953	0.012	
	Smoker	2.03	1.663	2.477	0.001	
	Quintile in PCT(1)	1.508	1.102	2.063	0.01	
	Quintile in PCT(2)	0.997	0.727	1.367	0.983	
	Quintile in PCT(3)	0.994	0.728	1.355	0.968	
	Quintile in PCT(4)	1.002	0.731	1.374	0.989	

a) Age (continuous); b) smoker (non-smoker ref cat); c) sex (male is ref cat); d) Quintiles of deprivation (Quintiles of deprivation- 5 is the least deprived and is the ref cat); e) non-exempt is ref category; p value< 0.05 is statistically significant

The findings in **Table 6-16** suggest that for every year of age patients had a 3% increased likelihood of having had a tooth extraction. Adults exempt from payment were 1.8 times more likely than non-exempt adults to have received a tooth extraction in the four-years ( $p=0.001$ ), whilst smokers were twice more likely to have had a tooth extraction than non-smokers ( $p=0.001$ ). Female patients were 20% less likely to have had tooth extractions than male patients ( $p=0.012$ ). Patients from the most deprived quintile in the PCT were 1.5 times more likely to have a tooth extraction in four academic years than the least deprived quintile in the PCT ( $p=0.01$ ). The ROC diagnostic area under the curve was 0.7 indicating that this model has a fair diagnostic capability.

### 6.5.8 Partial dentures multivariate model

**Table 6-17** shows the partial dentures regression results, which suggest that an adult's payment exemption status, age and smoking status, all predict whether a patient had a partial denture treatment in UPDA between 2008/09 and 2011/12 academic years. Quintile of deprivation and sex had no significant influence on whether a patient had received a partial denture in the study period.

**Table 6-17 Logistic regression model predicting partial denture treatment over academic years 2008/09 to 2011/12**

Outcome	Predictor variable	Odds ratio	95% C.I. for Odds ratio		P value	ROC area under the curve
			Lower	Upper		
Partial denture n=2,810	Adult payment exemption	2.604	1.758	3.856	0.0001	0.83
	Age	1.075	1.065	1.085	0.0001	
	Quintile in PCT(1)	1.087	0.655	1.802	0.748	
	Quintile in PCT(2)	0.813	0.484	1.365	0.433	
	Quintile in PCT(3)	0.927	0.561	1.531	0.767	
	Quintile in PCT(4)	0.704	0.412	1.205	0.201	
	Sex	0.688	0.941	0.698	1.268	
	Smoking status	3.142	2.277	4.337	0.0001	

a) Age (continuous); b) smoker (non-smoker ref cat); c) sex (male is ref cat); d) Quintiles of deprivation (Quintiles of deprivation- 5 is the least deprived and is the ref cat); e) non-exempt is ref category; p value< 0.05 is statistically significant

**Table 6-17** indicates that smokers are three times more likely to have had a partial denture treatment than non-smokers, while exempt adults were 2.6 times more likely to have a partial denture treatment. For every increasing year of age, adult patients had a seven per cent higher likelihood of having received a partial denture. The ROC area under the curve was 0.8; suggesting it was the best of the models undertaken.

## **6.6 Multilevel modelling predicting the influence of area of residence on the receipt of treatments**

In this section, the results of multilevel models undertaken to ascertain the influence of area of residence on receiving treatments was undertaken.

Three treatments were chosen for analysis due to the results of the single level models in section 6.5, which suggest that receiving these treatments could be predicted by quintile of deprivation in the PCT; which is a measure of deprivation based on place of residence.

The treatments selected were:

- i. Instruction /Advice
- ii. Scale/polish
- iii. Tooth extractions

### **6.6.1 Patients**

The number of patients included in these analyses was 3,947; these were adult patients from Portsmouth wards only. These were patients in main data set covering academic years 2008/09 to 2011/12. The area level measure selected was Lower Super Output Area (LSOA) - which was explained in 4.3.8.1 as a census area measure. The patients were restricted to Portsmouth only because it was necessary to have patients represented in every area analysed, and patients from outside Portsmouth may have at times been one per LSOA, which was not adequate for multilevel analysis. There are 123 LSOAs in Portsmouth. Details of multilevel analysis were outlined in section 4.4.7.5.

### **6.6.2 Multilevel model of Instruction/advice at LSOA**

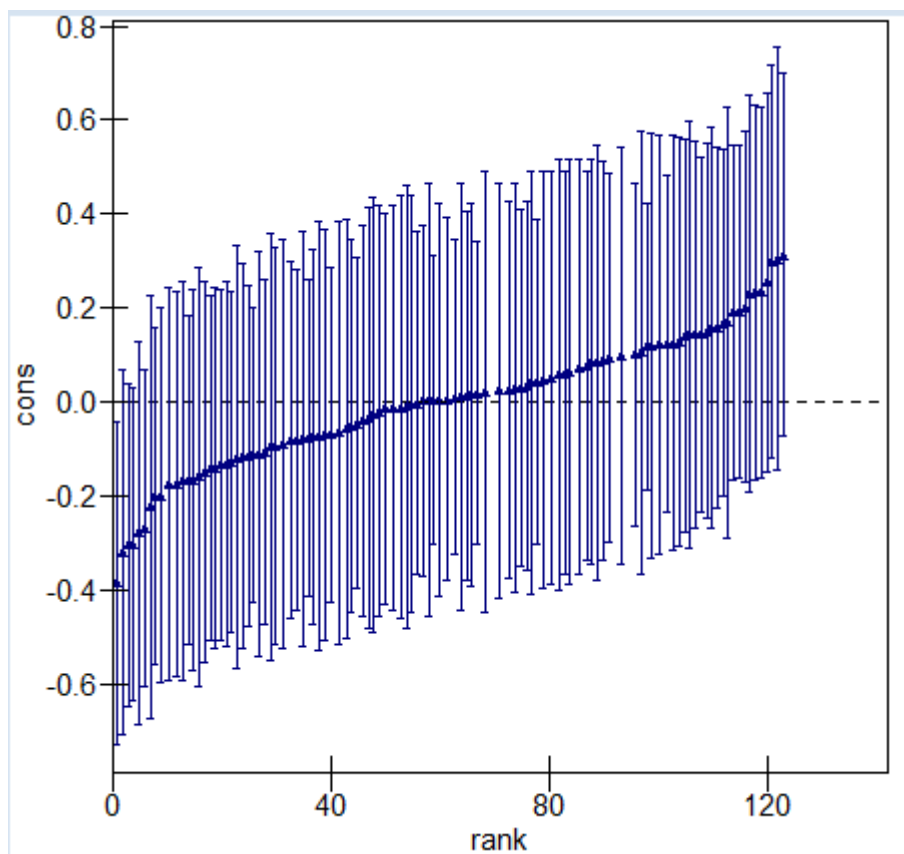
The first multilevel model was a null model to test the difference in probability of receiving instruction/advice treatment over academic years 2008/09 to 2011/12 at UPDA based on LSOA of residence or to ascertain the percentage of the variance in instruction/advice that could be attributed to a patient's LSOA.

The results of the null multilevel model showed statistically significant variance in instruction advice at the area level (LSOA). It showed that there was variance 0.062 SE 0.024 (Wald 40.415,  $p=0.0001$ ). The  $\beta_{0j} = -0.263(0.041)$   $p= 0.0001$ . The variance partition co-efficient

(VPC), which is the proportion of variance in instruction/advice that can be attributed to LSOA was 0.07, indicating that 7% of the variance in proportion of patients who had received instruction/advice can be explained by LSOA.

Although there is a significant influence of LSOA on the prediction of instruction/advice, a single model was considered as fitting as there was a small variance attributed to LSOA, which did not impact on the co-efficient in the prediction equations.

Afterwards the ranked residuals were plotted. These are the differences between the proportion of instruction/advice in one LSOA and the average proportion of instruction/ advice for all the adult patients from Portsmouth. The plotted results were for all adult patients only from Portsmouth. The results in **Figure 6-16** show a linear difference in the residuals within the 123 LSOAs.



Note: represents the ranked 123 LSOA according to the difference in mean from the average mean of all LSOA

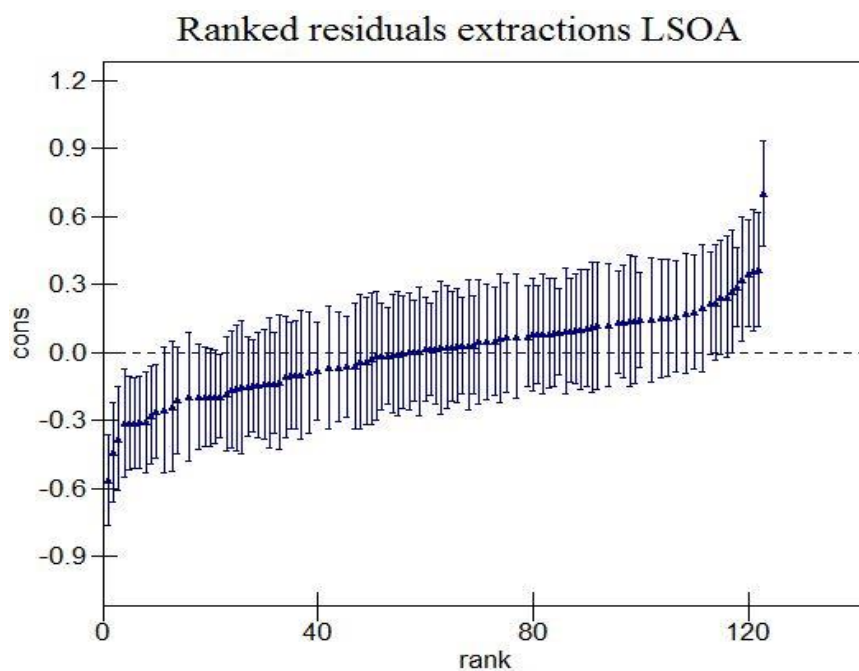
**Figure 6-16 Ranked residuals of proportion of instruction/advice by LSOA**

### 6.6.3 Multilevel model of tooth extractions at LSOA

A null model testing the influence of LSOA of residence was iterated to ascertain the percentage of the variance in extraction that could be attributed to a patient's LSOA. The null model described statistically significant variance in tooth extractions at the area level (LSOA). It showed that there was variance 0.097, SE 0.033 (Wald 4.229,  $p=0.003$ ). The  $\beta_{0j} = -0.194$  (0.048);  $p=0.0001$ . The VPC calculated was 0.028 indicating that 2.8% of the variance in proportion of patients who had received of tooth extractions can be explained by LSOA.

Although there is a significant influence of LSOA on the prediction of tooth extractions, a single model was considered as fitting as the small variance attributed to LSOA did not impact on the co-efficient in the prediction equations.

A caterpillar plot of ranked residuals was plotted: Figure. These are the differences between the proportion of tooth extractions in one LSOA and the average proportion of tooth extractions for the whole of Portsmouth.



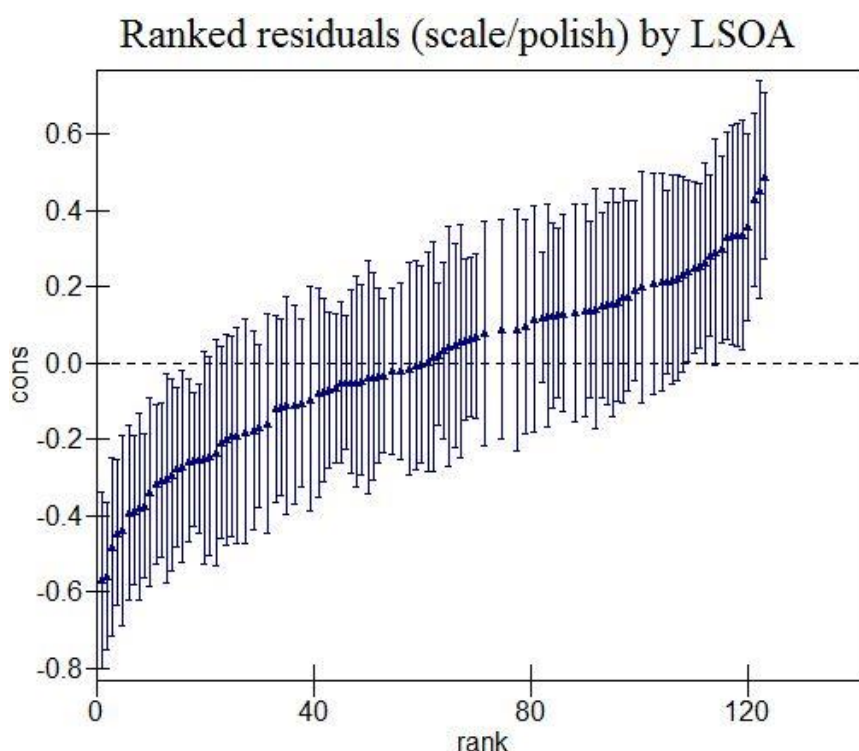
Note: represents the ranked 123 LSOA according to the difference in mean from the average mean of all LSOA

**Figure 6-17 Ranked residuals LSOAs tooth extractions in Portsmouth**

The plotted results were also for adult patients only from Portsmouth. This shows a linear difference in the residuals within the 123 LSOAs. A relatively large number of LSOAs at both ends of the graph have residuals and confidence well above or below the average for all LSOA.

## 6.7 Multi-level model of scale and polish at LSOA

Scale and polish multilevel regression null model, took into account any statistically significant variance in proportion of scale and polishes at the area level (LSOA). The results of the equation showed that there was variance 0.125, SE 0.034; Wald 12.505,  $p=0.0001$ . The  $\beta_{0j} = -0.317$  (0.048). This suggested that there was a statistically significant influence of LSOA of residence on receiving of a scale and polish. The VPC calculated was 0.036 indicating that 3.6% of the variance in tooth extractions can be explained by LSOA. Ranked residuals for LSOA and scale and polish are shown in **Figure 6-18**



Note: represents the ranked 123 LSOAs according to the difference in mean from the average mean of all LSOAs

**Figure 6-18 Ranked residuals of LSOA scale and polish in Portsmouth**



## 6.8 Health deprivation as a predictor of dental treatment need

Further logistic regression analyses to ascertain whether any general health indicators measured at the area level (LSOA) were associated with the treatments analysed in the MLA in Section 6.6.

- i. Instruction advice
- ii. Scale/polish
- iii. Tooth extractions

Health deprivation score of patient's LSOA of residence was selected as the area level measure for investigation. Details of this variable were outlined in section 4.3.8.1. The model included individual level predictors of treatment such as age, exemption status and smoking. The regression models adjusted for the effects of each variable.

### 6.8.1 Patients

Adult patients from the area of Portsmouth who had attended and completed at least one treatment plan and whose details were in the main data set covering academic years 2008/09 to 2011/12. The number of patients in the analyses of instruction/advice and scale/polish was 2,782 and for tooth extraction was 2,062.

### 6.8.2 Instruction/advice and health deprivation: Multivariate model

The multivariate logistic regression model predicting instruction/advice in a patient's treatment plan in the four-year study period and including health deprivation score as a predictor is presented in **Table 6-18**.

**Table 6-18 Logistic regression model of instruction/advice with an area level outcome measure: health deprivation included as a predictor**

Outcome : Instruction/advice n= 2,782	Odds ratio	95% C.I. for odds ratio		P-value
		Lower	Upper	
<b>Adult exemption status</b>	2.332	1.595	3.41	0.001
<b>Age</b>	1.036	1.03	1.043	0.001
<b>Health deprivation score</b>	0.553	0.478	0.64	0.001
<b>Sex</b>	1.195	0.995	1.436	0.057
<b>Smoker</b>	4.261	3.185	5.701	0.001

Age (continuous); b) smoker (non-smoker ref cat); c) sex (male is ref cat); d) Quintiles of deprivation (Quintiles of deprivation- 5 is the least deprived and is the ref cat); e) non-exempt is ref category f) health deprivation score is a continuous variable; p value< 0.05 is statistically significant

The findings suggest that exempt patients were twice as likely to have had instruction/advice as non-exempt. Older age increased likelihood of the treatment by 3.6% and a higher health deprivation score reduced the likelihood of having received instruction/advice by 50%. Smokers were four times more likely than non-smokers to have had instruction advice in the four-year period. All findings were significant at  $p=0.001$ . The ROC curve shows the area under the curve as 0.7 indicating a good model.

### 6.8.3 Scale and polish and health deprivation: Multivariate model

**Table 6-19** shows the influence area level health deprivation score has on receiving a scale/polish. The findings suggest that while controlling for other variables, patients with higher health deprivation had 0.6 less likelihood of receiving a scale/polish. Increasing age increased the likelihood of scale and polish in the four-year period by 3% per year. Adult exempt patients were 1.8 times more likely to receive a scale and polish in the study period than non-exempt adults, and smokers were 1.7 times more likely to have scale/polish than non-smokers. Sex had no significant effect on the model. The ROC curve showed that the model is fair (area under the curve 0.7).

**Table 6-19: Logistic regression model of scale/polish with an area level outcome measure: health deprivation included as a predictor**

Outcome : Scale/polish n= 2,782	Odds ratio	95% C.I. for odds ratio		P-value
		Lower	Upper	
Adult exemption status	1.793	1.344	2.392	0.001
Age	1.036	1.03	1.041	0.001
Health deprivation score	0.608	0.514	0.719	0.001
Sex	1.036	0.883	1.217	0.662
Smoker	1.766	1.443	2.161	0.001

a) Age (continuous); b) smoker (non-smoker ref cat); c) sex (male is ref cat); d) Quintiles of deprivation (Quintiles of deprivation- 5 is the least deprived and is the ref cat); e) non-exempt is ref category f) health deprivation score is a continuous variable; p value< 0.05 is statistically significant

#### 6.8.4 Tooth extraction and health deprivation: multivariate model

The results in the table below show that health deprivation scores do predict whether or not a patient receives an extraction as a part of their treatments in the study period. Those with higher health deprivation scores had a 20% increased likelihood of having had an extraction than those with a unit lower on their health deprivation score. Increasing age showed a 3% increased likelihood of experiencing an extraction within the four-year period. And smokers were two times more likely to have had an extraction than non-smokers, whilst exempt patients were 1.8 times more likely than non-exempt patients to have had a tooth extraction in the study period. Females were 20% less likely to have received extractions if all the other variables were controlled for. All findings were significant at the  $p < 0.05$  level. The ROC curve shows the area under the curve as 0.7 indicating a good model.

**Table 6-20: Logistic regression model of predictors of tooth extractions including health deprivation**

Outcome : Tooth extractions: n=2,062	Odds ratio	95% C.I .for odds ratio		p-value
		Lower	Upper	
<b>Adult exemption status</b>	1.849	1.406	2.431	0.001
<b>Age</b>	1.034	1.028	1.041	0.001
<b>Health disability score</b>	1.205	1.056	1.374	0.005
<b>Sex</b>	0.803	0.674	0.956	0.014
<b>Smoker</b>	2.106	1.67	2.656	0.001

a) Age (continuous); b) smoker (non-smoker ref cat); c) sex (male is ref cat); d) Quintiles of deprivation (Quintiles of deprivation- 5 is the least deprived and is the ref cat); e) non-exempt is ref category f) health deprivation is continuous (higher the score the more deprived in health); p value< 0.05 is statistically significant

## **6.9 Summary of patient base predictors of treatment need**

### **6.9.1 Introduction**

The chapter has reported the findings of the analytical study, which analysed the association between expressed needed treatments and socio-demographic factors. These results have identified the trend in volume and nature of demand in this primary care set. Such data would have significance on how to plan services and appropriate workforce. A comparison of some of the findings with the ADHS was undertaken to validate the results. These are shown in Appendix 10.6.22.

All the results reported and summarised here were analysed using the main data set (academic years 2008/09 to 2011/12). A total of 6,351 patients were included and 10,371 closed/completed treatment plans were analysed from UPDA over the four academic years

### **6.9.2 The patient base and treatments overall**

The patient base represented in this analysis covered a wide spectrum socio-demography with the age range of 1-94 years. Sixty-nine NHS treatment titles were isolated from the data, of which twenty treatments accounted for 96% of all the 147,417 observed treatments. Instruction/advice was the most frequent treatment provided. But the treatment received by the highest proportion of patients was tooth restoration followed by instruction/advice. Treatments in support of the periodontium, i.e. scale and polish and periodontology then followed.

The socio-demography and smoking status of patients was found to predict expressed treatment need within the four years. The analysis confirmed statistically significant associations between patient characteristics such as age, adult payment exemption, smoking, and quintile of deprivation of residence within the PCT, while controlling for confounding from each variable. Nine treatments were analysed using bivariate analysis against patient characteristics. Out of these; five were selected for detailed multivariate analysis as detailed in 4.4.7.4. The findings are summarised below.

### **6.9.3 Demand for treatment (expressed treatment needs)**

The proportion of patients who had received each of the following treatments at least once in the four years was as follows: Tooth restorations (52%): Instruction/ advice (49%):Scale/polish

(39%): Periodontology: non-surgical (32%): Tooth extractions (25.1%): Fissure sealants (13.1%): Endodontics (7%): Partial dentures (5%): Crown and Bridge (2.8%).

#### **6.9.4 Treatment, socio-demography, smoking and area level factors**

The propensity for treatment need based on patient characteristics is summarised here by outlining statistically significant relationships,  $p < 0.05$ , between patient characteristics and treatments which underwent logistic regression analysis (tooth restorations, instruction/advice, scale/polish, tooth extractions, partial dentures). The likelihood of receiving any of the treatments was assessed based on the four year period.

##### **6.9.4.1 Age**

Age was associated with increased treatment needs. Tooth restorations were most prevalent among 45-54 year-olds and 55-64 year-olds. Logistic regression suggested that with increasing age there was a 2% increase in likelihood of having received a tooth restoration in the four years. Instruction/advice had been received by majority of patients between the ages of 3-12 years and over the age of 45, with the regression suggesting 3.8% increased likelihood of instruction advice for increasing age. Scale and polish had been received by majority of patients over the age of 45 and with increasing age there was a 3.7% increased likelihood of having received a scale/polish in the four years. Tooth extractions had been received in the highest proportion among 65-74 year olds (49%) and there was a significant 3% increased likelihood of having received a tooth extraction with increasing age. Partial dentures were most commonly undertaken on over 75 year's olds and there was a 7% increased likelihood of having received a partial denture with increasing age.

##### **6.9.4.2 Adult payment exemption status**

The regression analysis which controlled for all other variables suggested that exempt patients were significantly more likely to have received the five treatments analysed compared with non-exempt. For tooth restorations (x2), instruction/advice (x2), scale/polish (x1.7), tooth extraction (x1.8) and partial dentures (x2.6).

#### **6.9.4.3 Sex**

Females were 20% less likely to have received a tooth extraction or a tooth restoration than males in the four year. Exempt males were 4 times more likely than non-exempt males to have received a tooth restoration, while exempt females were only 1.5 times more likely than non-exempt females. Tooth extraction was predicted by smoking in both males and female, however, male smokers were 2.5 times more likely than male non-smokers to have received a tooth extraction, while female smokers were 1.5 times more likely than female non-smokers.

#### **6.9.4.4 Deprivation**

For Instruction/ advice the least deprived quintile had the highest proportion of patients who had received instruction/advice and there was a clear gradient which on logistic regression was maintained as statistically significant. Tooth extractions were significantly higher 2% higher than in the most deprived quintile when compared with the least deprived. Scale and polish was significantly received at a higher proportion in patients who were less deprived when compared with 1<sup>st</sup> most deprived and the 3<sup>rd</sup> most deprived quintiles. Whilst tooth restorations were more likely among the two most deprived quintiles compared with the least deprived. For partial dentures the most deprived quintile were 1.5 times significantly more likely to have received a partial denture treatment in the four years.

#### **6.9.4.5 Smoking**

Smokers when compared with non-smokers were significantly more likely to receive the common treatments analysed: tooth restorations (57%), instruction/advice (x4), scale/polish (x1.7), tooth extraction (x1.8) and partial dentures (x2.6).

#### **6.9.4.6 Health deprivation**

Increasing health deprivation score significantly increased the likelihood of having received instruction/advice by 50% and tooth extraction by 20%, while it decreased the likelihood of having received scale/polish by 40%.

#### **6.9.4.7 Area level measures (LSOA)**

Multilevel analysis indicated that area of residence explained 7% of the variance in rate of instruction/advice, 3.8% in scale and polish and 2.8% of the variance in tooth extractions.

### 6.9.5 Other treatments investigated using chi-square analysis only

**Periodontology: Non-surgical:** adults who were non-exempt from NHS payment had a higher proportion of patients who had received these treatments (38%) compared with exempt (36%)  $p=0.002$ . Older adults over the age of 65 had received periodontology: non-surgical treatments (49%), which was above the overall average of 32%. Only 8.2% of those under 18 years of age had received a periodontology: non-surgical treatment.

**Fissure sealants:** Based on univariate analysis a higher proportion of younger patients had received fissure sealants (35.6%), the highest being the 6-12 year old age groups and the 13-17 year olds. Non-exempt adults had significantly higher proportions of patients who had received at least one fissure sealants in the four-years.

**Endodontics:** Both working age and older age adults had the same proportion of patients who had received endodontic treatment (8%).

**Crowns:** Working age adults and older adults (over 65 years) had crowns a higher proportion of crowns than those under the age of 18 years as expected, and smokers had higher proportions of crowns compared with non-smokers.

**Health deprivation:** The relationship between receiving instruction/advice, scale/polish or a tooth extraction and health deprivation score, was analysed in a single level multivariate model. The results show that increasing health deprivation score was significantly associated with less likelihood of receiving a scale/polish and instruction/advice ( $p=0.001$ ), whilst the same variable was associated with increased likelihood of having had an extraction within the four-year period ( $p=0.025$ ).

From all these findings the summary is that socio-demography is relevant when attempting to predict treatment needs, which in turn contribute to the demand on services.

## Chapter 7 Skill Mix and Treatment Mix

### 7.1 Introduction

This chapter reports on the results obtained from Study 4] **Figure 7-1**. Two data sets were used in the analyses. The first data set was derived from the main data set and included only patients who had received procedures that were coded by provider of care as explained in section 4.4.8. The second data set used was supplemental data manually collected from the live patient management data at UPDA described in the methods section 4.3.8.4 and was used to address the third objective:

*Objective 3:* To examine the skill mix practice at UPDA in relation to patient socio-demography and treatments provided during team training.

The first section of this chapter describes the patient characteristics in the sample from the main extract data. Second is the characterisation of delegation of patients to HTS from the findings in the main data set. Third is the delegation of treatment tasks and this includes main data set and supplemental data. Fourth is the univariate analysis of selected tasks and socio-demography. Some of the findings from Study 4 have been *published in a peer reviewed journal* See appendix 10.6.23

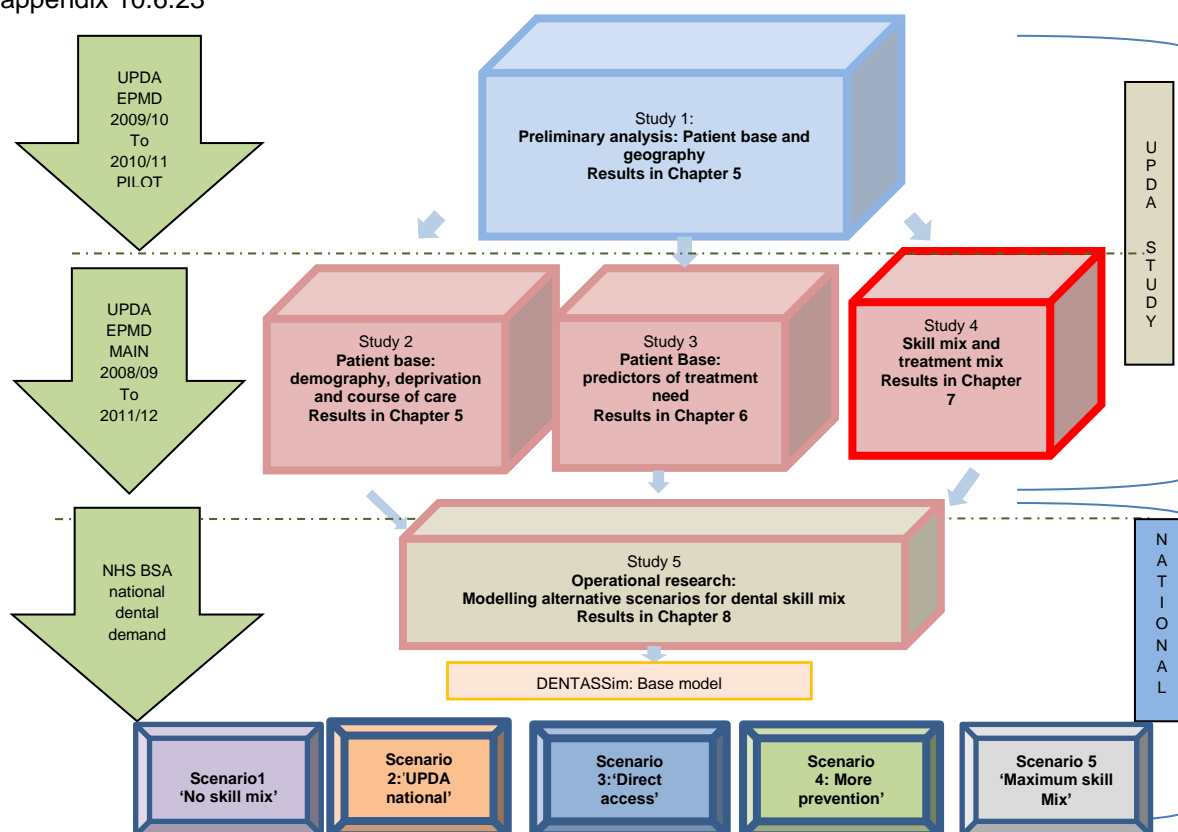


Figure 7-1 Studies-Chapter7-Study 4 results



## 7.2 Patients

This main data set covering the first two years of team training [academic years 2010/11 and 2011/12] was used to analysis how skill mix was used to manage patients. The 'skill mix data', were derived from isolating higher level treatments that had been coded by provider [Section 4.4.8]. The data included 2,063 patients who had undergone 14,996 treatments that identified the provider of care (coded for skill mix). The mean age was 39 (S.D 18.9); range 2-90 years. The mean IMD score was 22.7(S.D:14); range 1.18-63.54. Characteristics of the patients in the data set are shown in **Table 7-1**.

**Table 7-1 Characteristics of patient in main data extract academic years 2010/11 and 2011/12**

Variable		Frequency N=2,063	Per cent
<b>Age groups</b>	<b>0-2yrs</b>	1	0
	<b>3-5yrs</b>	8	0.4
	<b>6-12yrs</b>	186	9
	<b>13-17yrs</b>	87	4.2
	<b>18-24yrs</b>	242	11.7
	<b>25-34yrs</b>	404	19.6
	<b>35-44yrs</b>	319	15.5
	<b>45-54yrs</b>	337	16.3
	<b>55-64yrs</b>	265	12.8
	<b>65-74yrs</b>	150	7.3
	<b>over 75yrs</b>	64	3.1
<b>Payment Exemption</b>	<b>Non-exempt</b>	1,569	76.1
	<b>Exempt</b>	464	23.9
<b>Sex</b>	<b>Female</b>	926	44.9
	<b>Male</b>	1,137	55.1
<b>Quintile of deprivation ( n=2,043)</b>	<b>most deprived</b>	445	21.6
	<b>2</b>	423	20.5
	<b>3</b>	483	23.4
	<b>4</b>	450	21.8
	<b>least deprived</b>	242	11.7

Note:

1. n=2,063 unless otherwise stated
2. Bold numbers represent statistically significant differences
3. Data set used in this analysis is of 2,063 patients with known instances of delegation

### 7.3 Patient delegation by socio-demography

The relationship between delegation and socio-demography was revealed by analysing the proportion of patients who had at least one of the treatment items in their treatment plans delegated (coded HTS). Fifty-five per cent (1,134) of patients had evidence of at least one instance of delegation. The results of the univariate analysis of patient delegation rate and socio-demography are shown in Table 7-2 below.

**Table 7-2 Group differences in delegation of patients**

		No delegation		Delegation		P value
		N	%	N	%	
<b>Delegation Overall</b>		929	45.0	1134	55.0	
<b>Payment status</b>	<b>Non-exempt</b>	793	50.5	776	49.5	<b>0.01</b>
	<b>Exempt</b>	136	27.5	358	72.5	
<b>Age groups</b>	<b>Under 18</b>	41	14.5	241	85.5	<b>0.001</b>
	<b>18-64yrs</b>	797	50.1	793	49.9	
	<b>Over 65</b>	91	47.6	207	56.6	
<b>Sex</b>	<b>Female</b>	1,702	54.9	1,396	45.1	0.418
	<b>Male</b>	1,820	55.9	1,433	44.1	
<b>Quintiles of deprivation based on patient population (2,043)</b>	<b>Most deprived1</b>	200	44.9	245	55.1	0.988
	<b>2</b>	192	45.4	231	54.6	
	<b>3</b>	222	46.0	261	54.0	
	<b>4</b>	199	44.2	251	55.8	
	<b>Least deprived 5</b>	108	44.6	134	55.4	

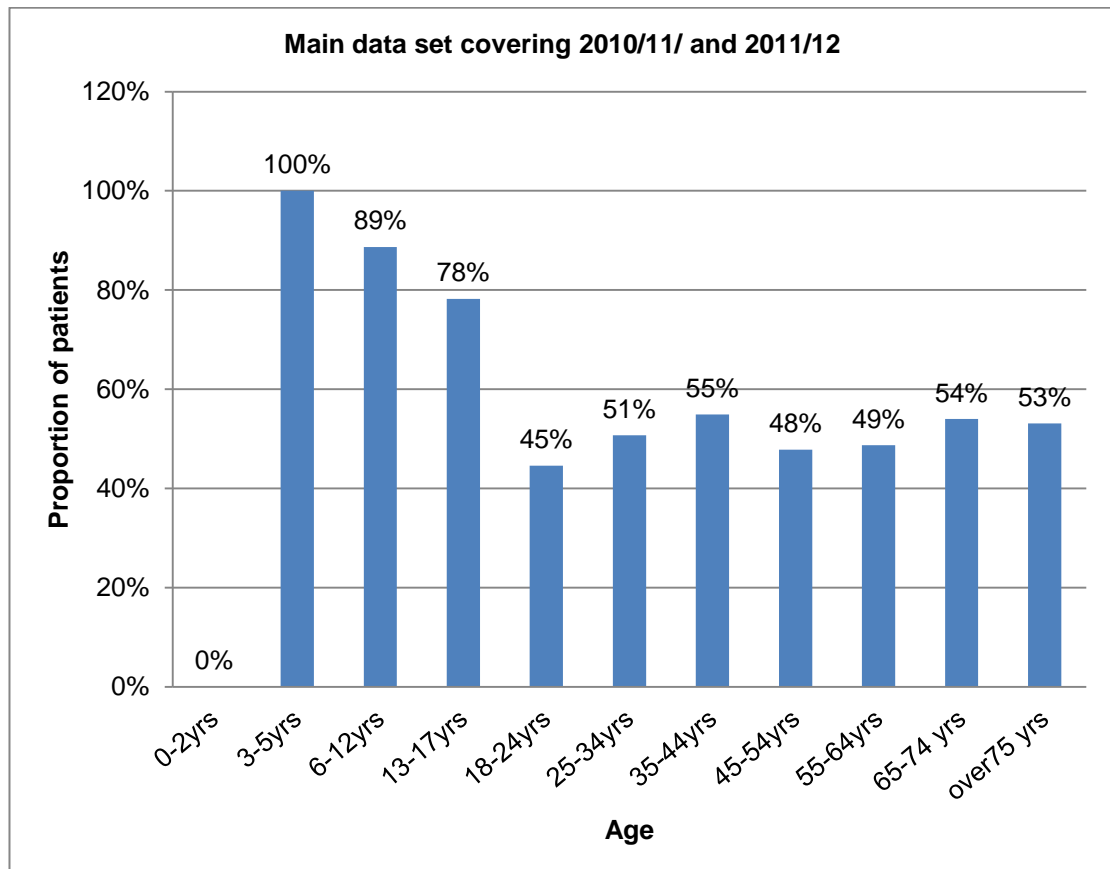
Note:

1. n=2,063 unless otherwise stated
2. Bold numbers represent statistically significant differences
3. Data set used in this analysis is of 2,063 patients with known instances of delegation

**Table 7-2** findings indicate that there was a significant difference in rate of delegation between patient groups, which was associated with a patients' age and payment status. Also found were significant differences in the rate of delegation by patient age group; with children under the age of 18 being delegated at a higher rate compared with adults. Other findings showed that smoking status, as ascertained by the smoking cessation variable, showed that a significantly higher proportion of adult patients only who had been signposted to smoking cessation had been delegated compared with non-smokers (56% cf 46%: p= 0.01).

### 7.3.1 Age and delegation

From the results shown in **Table 7-2** patients under the age of 18 had higher delegation rates (85%), compared with working age adults (19-64 years) (49%) and older adults (54%);  $p=0.001$ . A more detailed analysis of the difference in delegation by age groups was undertaken and the results presented in **Figure 7-2**.



Note:

1.  $n=2,063$  unless otherwise stated
2. Bold numbers represent statistically significant differences
3. Data set used in this analysis is of 2,063 patients with known instances of delegation

**Figure 7-2 Proportion of patients by age group who had been delegated at least once in the two academic years**

**Figure 7-2** indicates that 100% of 3-5 year olds had been delegated to HTS at least once in the first two years of team training, based on the selected tasks. The 18-24 year olds had the lowest rate of delegation. Amongst adult patients, the 35-44 year age group had the highest level of delegation (55%).

### 7.3.2 Logistic regression model predicting delegation by patient socio-demography

A logistic regression model using Wald technique tested whether age, payment exemption status, sex and quintile of deprivation in the PCT were predictors of delegation to HTS. The results presented in **Table 7-3** below shows that exemption status (adult and child) was a statistically significant predictor of delegation, with those exempt being two times more likely to have been delegated than non-exempt. Age was also a significant predictor of delegation with younger patients being 1% more likely to be delegated. When the analysis is undertaken on adult patients only, the findings suggest that exemption is not statistically significant. Age maintains the same prediction value even when adult exemption is used. The model itself controls for the effects of the other variables.

**Table 7-3 Logistic regression model of delegation predicted by patient socio-demography**

Outcome	Predictor variable	Odds ratio	95% C.I.for Odds ratio		P value
			Lower	Upper	
Delegation n=2,063	Age	0.994	0.989	0.999	0.025
	Exemption status	2.383	1.866	3.044	0.001

Note: a) age is continuous b) exempt is the reference category

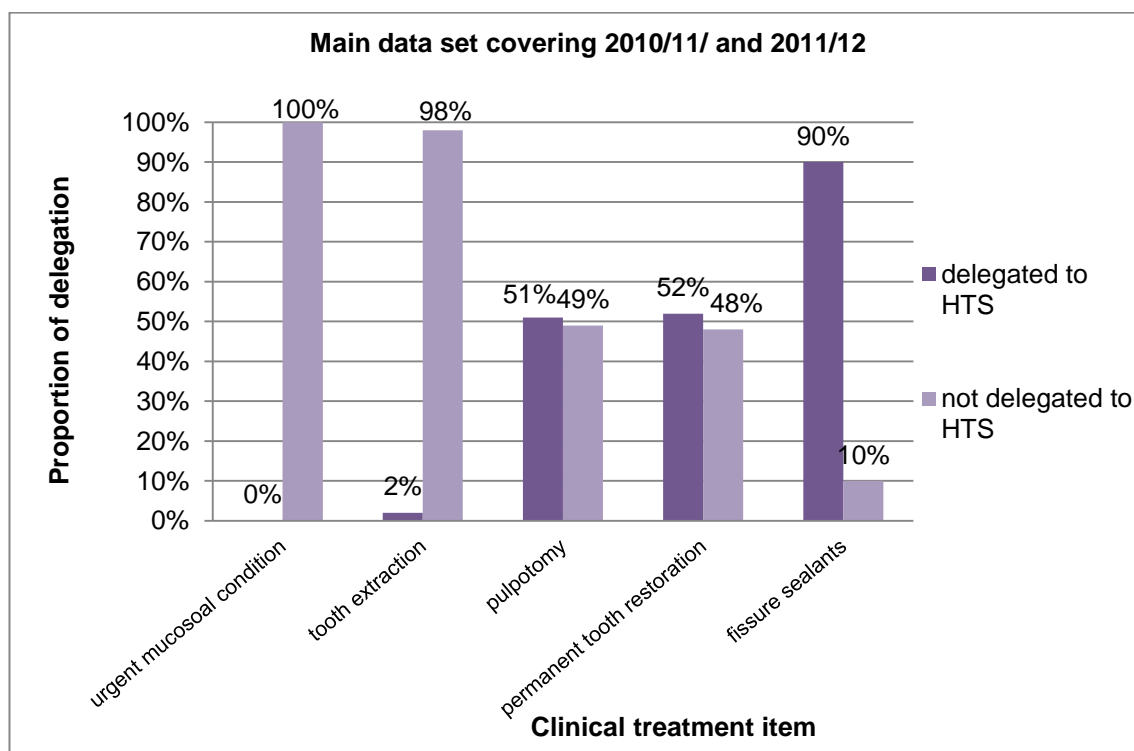
## 7.4 Skill mix: delegation of clinical tasks [main data set]

This section reports on the delegation of clinical tasks as ascertained from the main data set covering 2010/11/ and 2011/12. These are higher level selected tasks only, which had been coded by provider of care ('coded for skill mix'). The treatment included:

- i. Urgent mucosal conditions
- ii Paediatric tooth extractions
- ii.Pulpotomies (root canal treatment on children's teeth)
- iv Permanent tooth restorations
- v.Fissure sealants

Out of the possible 14,996 operations that could have been delegated, 47% in 2010/11, and 46% in 2011/12 were delegated to HTS. The nature of operations that were potentially delegated covered the full scope of the HTS skill set.

**Figure 7-3** shows the rate of delegation by treatment.



Note:

- 1 .n=2,063 unless otherwise stated
- 2 .bold numbers represent statistically significant differences
3. Data set used in this analysis is of 2,063 patients with known instances of delegation

**Figure 7-3 Proportion of delegation by clinical item**

**Figure 7-3** showed that preventative procedures such as fissure sealants were more freely delegated (90%) than all other procedures. Tooth restorations were delegated at a high rate (52%), closely similar to pulpotomies (endodontic treatment on primary teeth) (51%). Appendix 10.6.15 gives details of the number of treatments in each category that was analysed.

In section 7.5, the findings from the analysis of the supplemental data are reported and these cover the delegation of two treatments; scale and polish and fluoride varnish which had not been coded for skill mix in the main data extract as described in Section 4.3.8.4 of the Methods.

## 7.5 Skill mix: delegation of clinical tasks (supplemental data set)

The supplemental data were used to show how scale and polish and fluoride varnish treatments were delegated, as these procedures were not coded for skill mix in the main data set. A random selection 100 records was used in the analysis as described in Section 4.4.8.

Overall 88% of the patients had at least one instance of delegation. The cases were classified according to three categories; basic restorative, advanced restorative and stabilisation (of disease). Of the patients who had been delegated, 40% were stabilisation cases, 45.9% were basic restorative and 14.1%, were advanced restorative cases. **Table 7-4** shows the difference in proportion of patients within different socio-demographic categories.

**Table 7-4 Characteristics of patients in supplemental data of 100 cases**

Patients socio-demography	Groups	% of patient
Age groups	0-2 yrs	2
	3-5 yrs	1
	6-12 yrs	5
	13-17 yrs	3
	18-24 yrs	16
	25-34 yrs	16
	35-44 yrs	11
	45-54 yrs	25
	55-64 yrs	13
	65-74 yrs	7
	75yrs and over	1
Exemption status	Children	11
	Non-exempt	88
	Exempt	1
Sex	Male	52
	Female	48
Smoker	Non-smoker	69
	smoker	31

Note: Data set used in this analysis is of 100 supplemental data

### 7.5.1 Scale/polish and fluoride varnish delegation

The results shown below in **Table 7-5** indicate that although overall 85% of the patients required a scale and polish 91.8% (78) were delegated to HTS. The number of patients who had a plan

for fluoride varnish were 66 but only 61 were delegated, which suggested a 92.4% rate of delegation of fluoride varnish cases.

**Table 7-5** shows details of delegation patterns including the proportion of patients overall who required a scale and polish or fluoride varnish.

**Table 7-5 Delegation of scale and polish and fluoride varnish**

Procedure	Overall proportion of patients who needed procedure	number of patients delegated	proportion of delegation
Scaling and polishing	85%	78	91.8%
Fluoride varnish	66%	61	92.4%

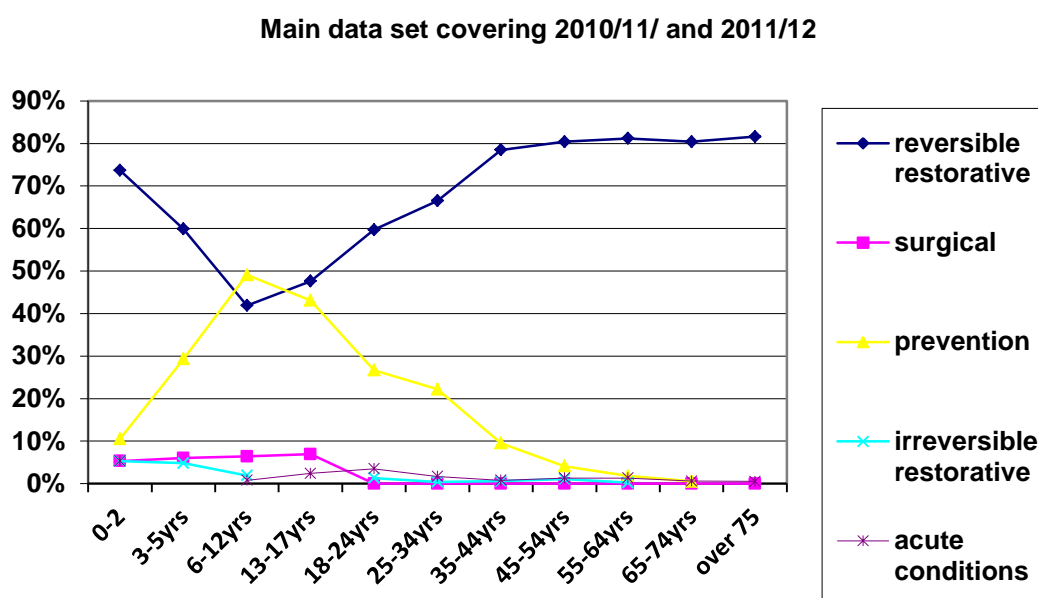
Note:

Data set used in this analysis is of 100 supplemental cases, randomly selected from the UPDA patient management system



## 7.6 Clinical tasks and age

Age appeared to be a significant influence on delegation [rate section 7.3.1]. A pattern of higher delegation for younger children was shown. Following this finding a more detailed analysis was undertaken to ascertain whether the nature of treatments needed in each age group could have been related to rate of delegation. **Figure 7-4** presents the findings below.



Note:

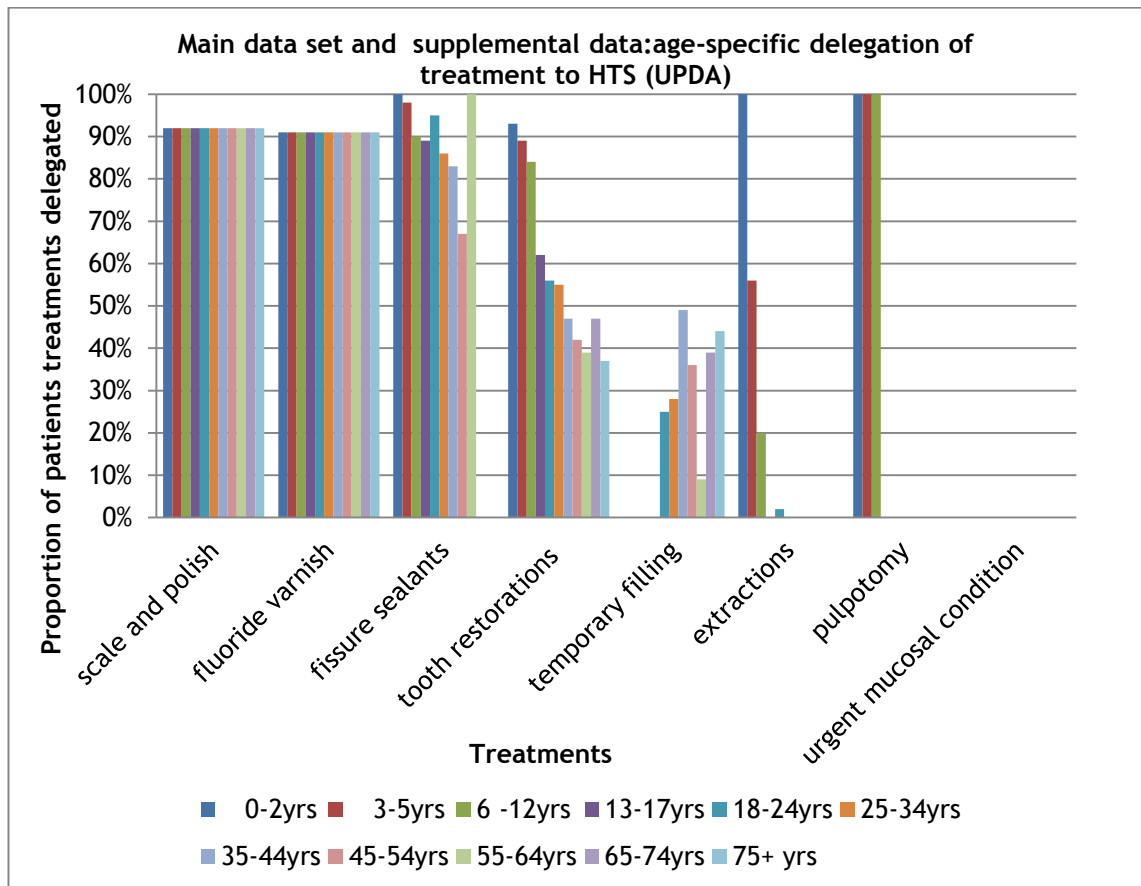
1. n=2,063 unless otherwise stated
2. Bold numbers represent statistically significant differences
3. Data set used in this analysis is of 2,063 patients with known instances of delegation

**Figure 7-4: Proportion of Treatments by age bands (from identifiable delegation data set)**

**Figure 7-4** showed that prevention is more common in the younger patient groups and reversible restorative procedures are the most common treatments in working age and older patients. The patients aged 18-24 years who were shown to have the lowest proportion of patients who had been delegated, are shown to have the least proportion of restorative tasks as part of their care compared with other adult groups.

An additional analysis showing delegation of treatments by age group was undertaken for each treatment group and the results are presented in Figure 7-5 below. The findings show the age-

specific treatment-specific delegation rates. These data were carried forward for use in the operational model.



Note: For scale and polish and fluoride varnish overall delegation rate was used for all age bands to avoid biases based on sample size.

**Figure 7-5 Age-specific delegation rate of treatments at UPDA**

## 7.7 Univariate analysis of skill mix and socio-demography for selected treatments

Two of the treatments which had skill mix coded in the main data set were isolated and patients who had experienced these treatments were analysed for differences in socio-demography and delegation. The treatments were selected due to a reasonable sample of patients having received the treatments to facilitate analysis.

- Tooth restorations
- Fissures sealants

### 7.7.1 Tooth restorations

A total of 1,692 of the patients who had received one of the procedures coded for skill mix had received tooth restorations. Overall 58.8% of tooth restorations that could be delegated, based on the skill mix coding, were delegated to HTS. There were statistically significant differences in the rate of delegation of skill mix by patient age groups and adult smoking status as presented in Table 7-6 below.

**Table 7-6 group difference in delegation of patients who received tooth restorations that were coded for skill mix**

		No del ega tion		Dele gati on		P value
		N	%	N	%	
<b>Delegation Overall</b>		590	42.2	841	58.8	
<b>Payment status n=1,414</b>	<b>Non-exempt</b>	523	41.3	744	58.7	0.93
	<b>Exempt</b>	60	40.8	87	59.2	
<b>Age groups</b>	<b>Under 18</b>	32	12.3	229	87.7	<b>0.001</b>
	<b>18-64yrs</b>	547	42	756	58	
	<b>Over 65</b>	43	33.6	85	66.4	
<b>Quintiles of deprivation based on patient population n=1,673</b>	<b>Most deprived1</b>	130	36.1	245	55.1	0.988
	<b>2</b>	125	36.7	231	54.6	
	<b>3</b>	146	37	261	54	
	<b>4</b>	137	36.6	251	55.8	
	<b>Least deprived 5</b>	77	37.9	134	55.4	
<b>Sex</b>	<b>Female</b>	285	37.8	469	62.2	0.428
	<b>Male</b>	337	35.9	601	64.1	
<b>Smoking status (adults) n=1,002</b>	<b>non-smoker</b>	337	44.1	428	55.9	<b>0.001</b>
	<b>smoker</b>	75	31.6	162	68.4	

Note:

1. n=1,692 unless otherwise stated
2. Bold numbers represent statistically significant differences
3. Data set used in this analysis is of 1,692 patients with known instances of delegation

**Table 7-6** showed that a significantly higher number of younger patients under the age of 18 who had received a tooth restoration which had been coded for skill mix were delegated (87.7%) compared with working age adults (58%) and older adults (59.2%). The table also shows that smokers were also delegated at a higher rate than non-smokers (p=0.01).

### 7.7.2 Fissure sealants

A total of 178 patients had received fissure sealants that were coded for skill mix. There were statistically significant differences in delegation by sex of patients, with female patients more likely to be delegated for fissure sealants, coded for skill mix, than males. Deprivation, smoking and adult payment statuses were null, due to low expected values due to a small sample.

		No delegation		Delegation		P value
		N	%	N	%	
<b>Delegation overall</b>		15	8.4	163	91.6	
<b>Payment status</b>	<b>Non-Exempt</b>	7	9.3	68	90.7	n/a
	<b>Exempt</b>	1	20	4	80	
<b>Age groups N=1692</b>	<b>Children</b>	7	7.4	87	92.6	0.441
	<b>Adult</b>	8	9.5	76	90.5	
<b>Sex</b>	<b>Female</b>	3	3.8	76	96.2	<b>0.047</b>
	<b>Male</b>	12	12.1	87	87.9	
<b>Quintiles of deprivation based on patient population (2,043) N=176</b>	<b>Most Deprived 1</b>	1	2.8	35	97.2	n/a
	<b>2</b>	1	2.8	35	97.2	
	<b>3</b>	7	16.7	35	83.3	
	<b>4</b>	4	9.1	40	90.9	
	<b>Least Deprived 5</b>	15	11.1	16	89.9	
<b>Smoking status  N=130</b>	<b>Non-Smoker</b>	13	10.8	107	89.2	n/a
	<b>smoker</b>	0	0	10	100	

Note:

1. n=178 unless otherwise stated
2. Bold numbers represent statistically significant differences
3. Data set used in this analysis is of 178 patients with known instances of delegation
4. n/a implies that the expected values were less than 5 invalidating a chi square test

### 7.7.3 Summary: Skill mix practice at UPDA

This chapter has described the skill mix pattern of practice during the team training period 2010/11 and 2011/12 at UPDA and has addressed *objective 3*. The findings suggest that 55% of 2,063 patients who received 14,996 clinical items of care, which could potentially be delegated to HTS, and were coded by treatment provider in the main data set, had at least one instance of delegation. In addition, 46% of treatment items that could be delegated were delegated within the same data set.

Significant associations were found between delegation and both age-group, exemption status and adult smoking status. Younger patients were delegated at a higher rate (85%) compared with working aged (49%) and older adults (51%);  $p=0.001$ . Payment exempt patients were twice more likely to be delegated than non-payment exempt ( $p=0.001$ ). And adult smokers were more likely to be delegated to the hygiene-therapists. The treatments most commonly delegated were fissure sealants (90%), followed by restorations (51%); whilst the least delegated were paediatric extractions (2.4%). The supplemental data suggested that scale and polish and fluoride were delegated at 91.8% and 92.4% respectively.

Investigation of relationship between demography and delegation within fissure sealants and tooth restorations showed that tooth restorations were delegated at a significantly higher rate for children and smokers, while fissure sealants were delegated at a significantly higher rate for females.

# Chapter 8 Operational research: Modelling alternative scenarios for skill mix in England

## 8.1 Introduction

This chapter describes the operational research exercise and the results of the alternative scenario testing (Study 5 results **Figure 8-1**). The results address the fourth objective of this research:

*Objective 4:* To examine the implications of findings from team training experiences for primary dental care nationally and test the potential for skill mix utilisation within NHS dental care.

The first section of the chapter describes the operational research (OR) model development process. Second is a description of all the OR model components/stages. Third, are the base model outputs. Fourth is the report of the scenario findings including cost analysis results, which leads to a final summary of the key findings.

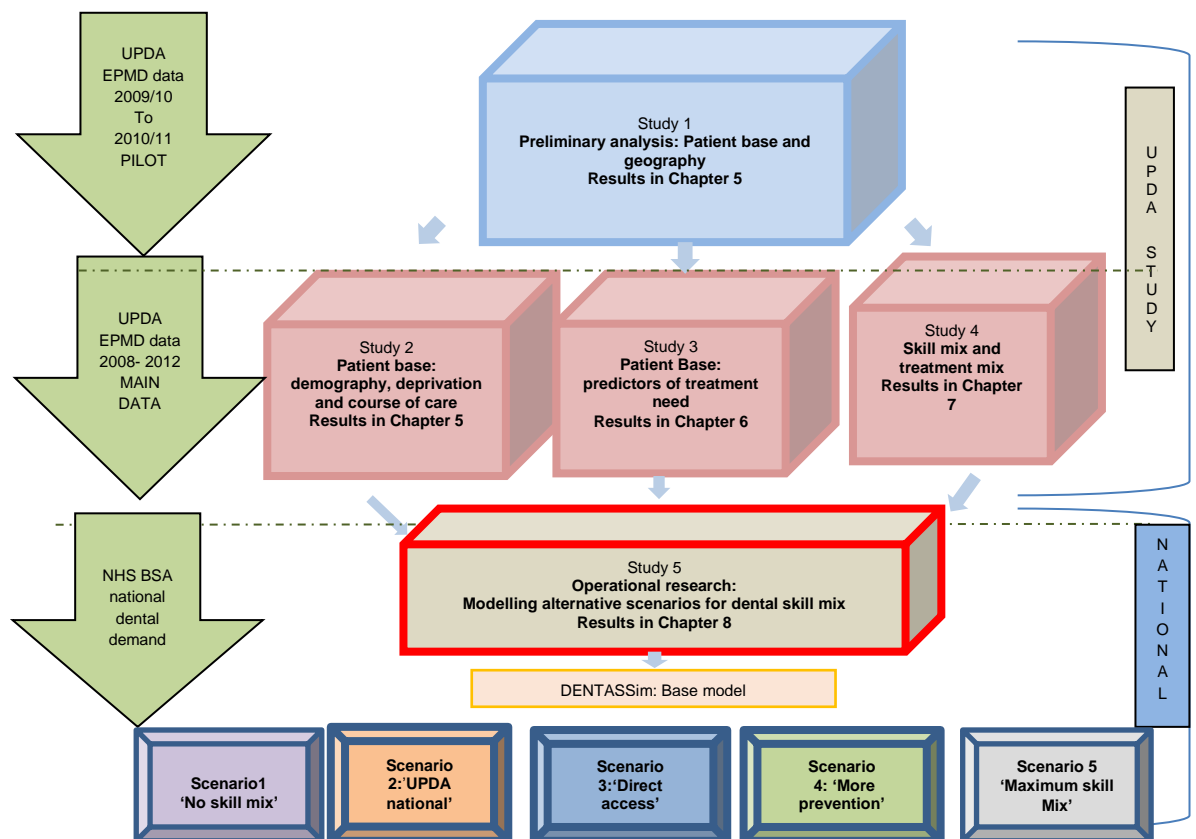


Figure 8-1 Studies- Chapter 8- study 5 results

## **8.2 Developing the OR model and alternative scenarios**

The operational research exercise involved the development of a supply and demand model that simulated how clinical time and skill can be shared between dental team members (particularly dentists and hygiene-therapists) nationally, while taking into account the predictors of dental treatment need and skill mix that were revealed through the study of UPDA data. In the next sections the findings considered for inclusion in the operational model are outlined

### **8.2.1 Evaluating UPDA findings and compatibility with a supply and demand model**

The findings from case study were evaluated for applicability within a supply and demand model for skill mix use in England. Only theoretically generalizable findings and nationally available data were considered for the model. The following sections report on the process of evaluation.

### **8.2.2 Patient base findings**

The pilot data were used to investigate the changes during transition, and to guide the development of a more robust second main extract. The results from the pilot study showed age associated influences on the demand for complex care (laboratory constructed devices) in both periods; before and after UPDA's establishment. This was the first of the findings from the UPDA analysis to introduce the idea of age as a predictor of treatment need and demand; making this a likely component of the OR model.

The influence of age on complex treatment need has been reported in literature as an expected outcome of an ageing population (Gallagher et al., 2010, Harper et al., 2013, Watt et al., 2013). Recommendations from experienced dental workforce modellers in England support the use of age-specific models for improved quality of the model (Harper et al., 2013, Gallagher et al., 2010). Further still, age-specific data linked to national dental demand is available, and this further promoted the idea of this as a model component; as any variable for use in a national operational model will require such linked data.

Other findings from the pilot data, such as the changes in relation to deprivation and geography, were not included in the model. This is because these differences were not stable, and changed in the second year post-expansion. Also, deprivation categories and geographical areas are not linked to national dental demand, i.e. the available data from the Business Services Authority. During the case study analyses of UPDA's data, these variables were derived from post-code

data extracted from the patient records following ethical approval and strict confidentiality protocols; these types of data would not be available on national dental data.

#### **8.2.2.1 Patient base and treatment need findings**

The findings from studies 2 and 3 also revealed age related differences in the distribution of treatments, and additionally described how socio-demographic factors were predictors of treatment need. The other factors, aside from age, were smoking status and adult payment exemption status. Although smoking status was viewed as a useful variable to include in the model, like deprivation scores, it was not linked to national dental demand data, although this would have been desirable. Adult payment status associated with completed treatment plans was linked to national data, but this variable was viewed as unsuitable for simulation, for three reasons: its dependence on temporal circumstance of the patient, its dependence on the patient's knowledge of eligibility, and inability to theoretically generalise the association to treatment established using UPDA's data, which could have been influenced by the free service policy. In many occasions, payment status is viewed as a proxy for deprivation score, and for this reason this may have been a useful variable to explore. However, it may have been more helpful to have actual deprivation scores, which give a broader description of circumstance.

#### **8.2.2.2 Skill mix findings**

The findings from Study 4 were a key component of the OR model. This is because these findings revealed patterns of how skill mix can work in a primary care setting; the data revealed varied delegation rates associated with patient type and treatment type. These were included in the model. These observed data on the productivity of hygiene-therapists, was an improvement from self-reported measures available from past literature (Jones et al., 2007b, Godson et al., 2009, Turner et al., 2011, Robinson et al., 2011), which could have been subject to survey bias such as recall bias and social desirability biases. With this in view, age-specific and treatment specific delegation rates were considered for the model, for the purpose of providing a detailed picture of how clinical time and WTE could be distributed through the use of skill mix.



### 8.2.2.3 Final findings included in model

The final components of the model were age-specific, treatment specific demand, delegation rate, timing of procedures and average national whole time working hours shows the process of findings evaluation and final components of the model.

**Table 8-1 Exclusion and inclusion of findings from the operational model**

Key findings	Excluded from model	Included in model
<b>Age and complex treatment are associated with advanced treatment</b>	Deprivation and Smoking status associated with treatment need and delegation rate excluded due to lack of national data linked to dental demand	Age associated with complex treatment
<b>Younger age associated with prevention</b>	Payment status associated with volume of treatment excluded due to lack of national data	Age associated with delegation rate
<b>Deprivation and smoking associated with higher acute treatment</b>		Treatment type associated with delegation rate
<b>Delegation rate related to age, treatment type and adult smoking status</b>		

Note: Findings outlined in sections 5.5, 6.9, and 7.7.3

In the next section the operational model that was developed is presented and each of the model components outlined in detail.

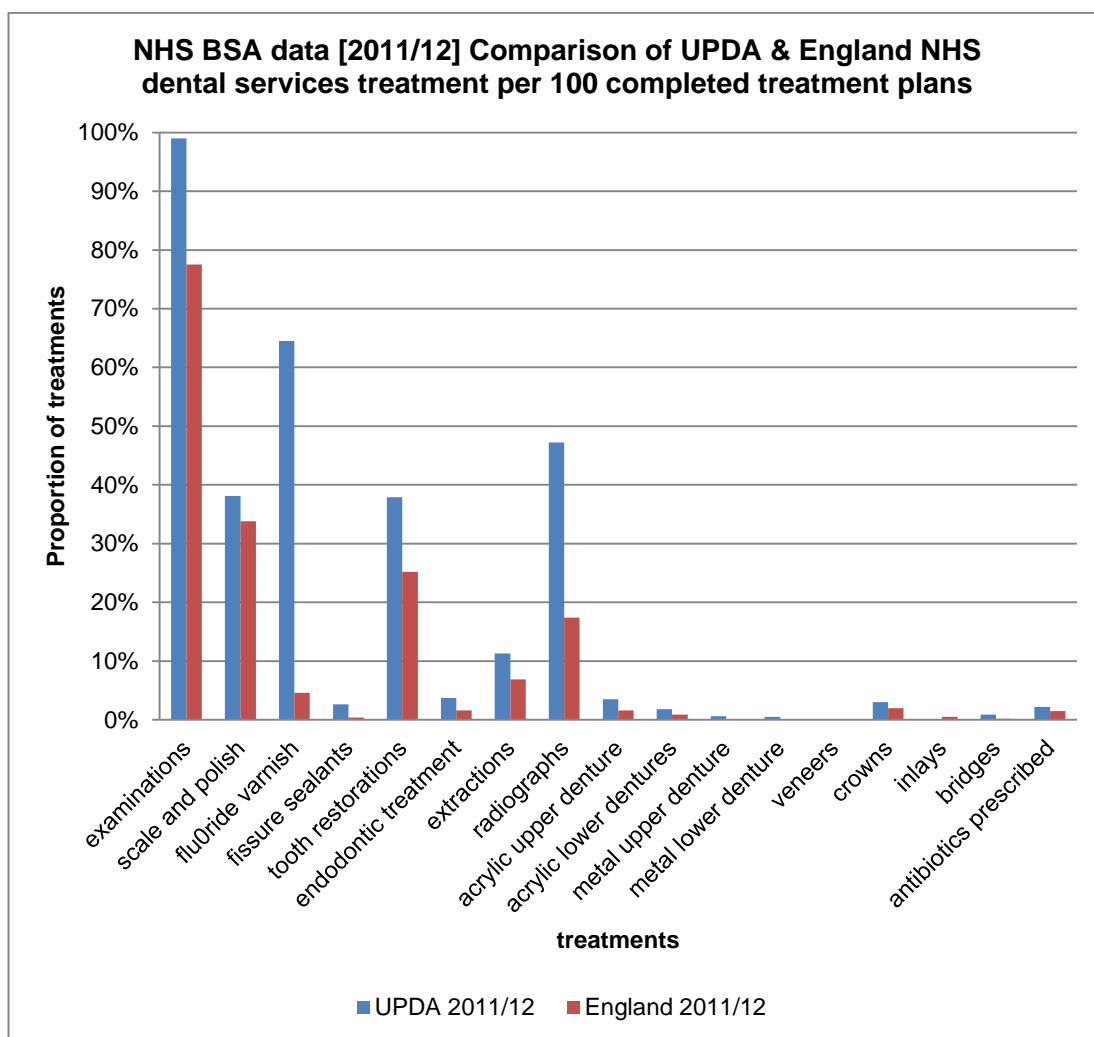
### 8.2.3 External validation of UPDA findings

First, a comparative analysis of UPDA findings with national data was undertaken, in order to justify the application of the learning from UPDA nationally. This was in an effort to ensure theoretically generalizability of findings. A system described by Yin (2009) as pattern matching was undertaken to ensure external validity and generalizability of case study findings. The process of pattern matching involved comparing UPDA findings related to treatment need and socio-demography to findings from previous research that were nationally representative. In this research, ADHS (2009) and NHS BSA data, were used as nationally representative data. Second, the findings from each of the UPDA studies were considered individually for their applicability in the model.

Only where comparable variables existed in ADHS 2009 reports and the UPDA findings was a comparative analysis possible. Two variables could be compared, namely age and self-reported treatment and patient's sex and reported treatment experience. Also, as ADHS was adult only data, only the findings related to adults from UPDA were compared. The results of the comparisons suggested similar patterns of peaks and troughs in age related treatment activity and treatment related to sex. The details are shown in the appendix 10.6.21. In the next section NHS BSA activity reports for Portsmouth compared to England are outlined.

#### **8.2.4 Comparing activity in Portsmouth to England**

An analysis of NHS BSA data describing treatment activity for the NHS year 2011/12 for UPDA compared to England was undertaken. The units of comparison were the volume of treatments for each treatment type per 100 courses of care/ treatment plans. These results provide a picture of what the team training activity translated to, in terms of overall treatment activity compared with England. The findings are shown in **Figure 8-2** below.



Source:  
NHS dental services end of year returns 2011/12

**Figure 8-2 Comparison of NHS BSA activity data [2011/12] UPDA and England**

**Figure 8-2** shows that in 2011/12 (2nd year of team training) the rate of all procedures is higher in UPDA compared to England. The rate of preventative tasks, which can be performed by both hygiene-therapists and dentists, was considerably higher per treatment plan in UPDA than in England. In the appendix 10.6.22 activity reports for the year 2009/10, which is the year before team training, are shown. Overall, this comparative analysis suggests that during team training, the range of tasks per treatment plan involved a considerable amount of prevention; higher than the national average. In the next section the operational model is described.

### 8.2.5 The operational model: Dental Treatment and Skill mix Simulation (DENTASSim)

The operational base model was referred to as a **Dental Treatment And Skill mix Simulation** model. This is because the model incorporates elements of dental treatment and skill mix use and provides a basis for simulation. As a shortened title it was referred to as DENTASSim. The DENTASSim model is a four-stage model whose main output is age-specific clinical hours for either dentists or hygiene-therapists.

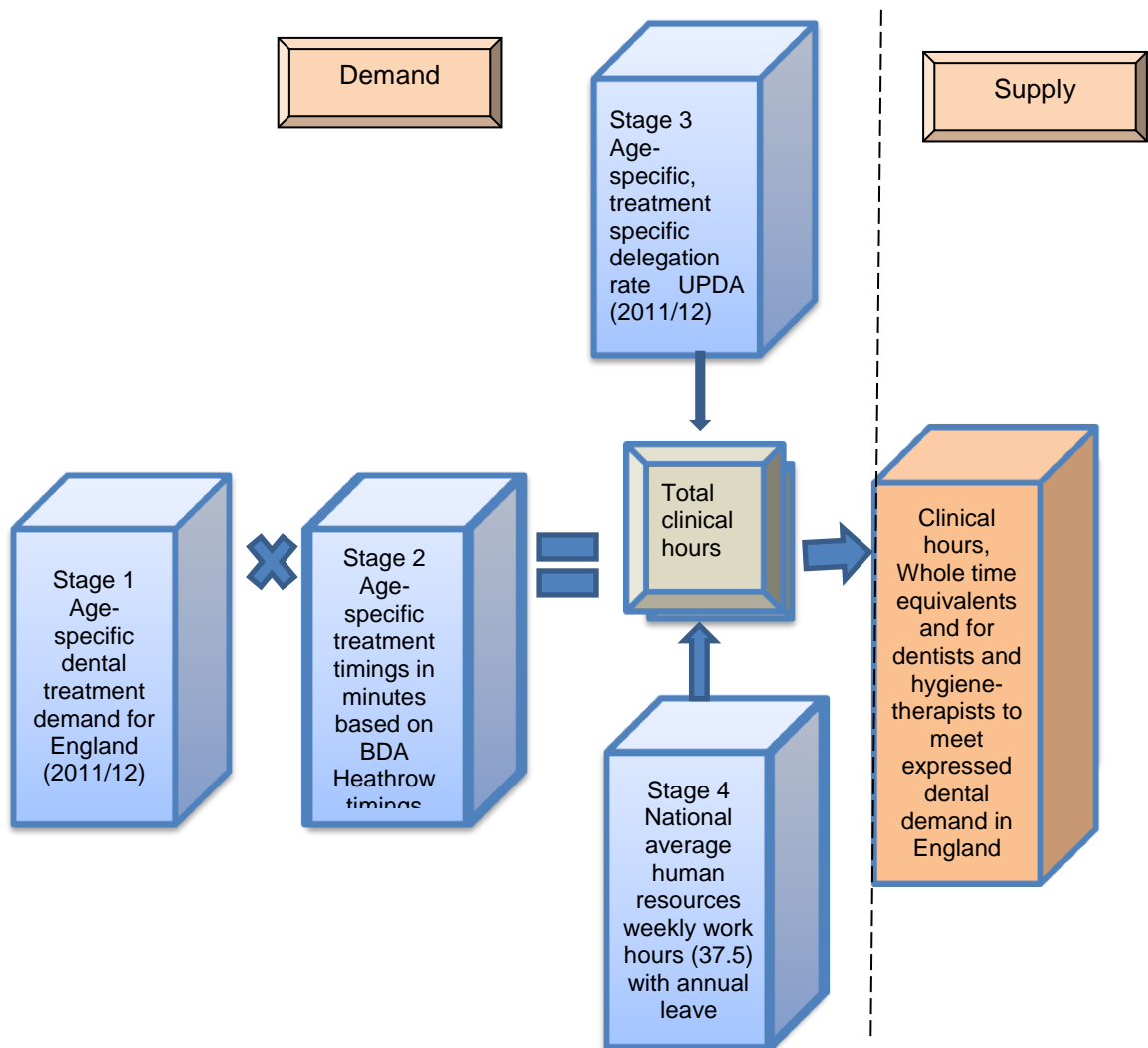


Figure 8-3 Operational supply and demand model [DENTASSim]

The model simulation was undertaken using linear operational equations on a spreadsheet. The model stages are listed below.

- i. **DENTASSim Stage 1 – Age-specific NHS treatment activity for England in the NHS year 2011/12:** This included 17 treatment groups. Data are provided by number of clinical items performed for each treatment group presented in **Table 8-2**
- ii. **DENTASSim Stage 2 – Age-specific treatment timings:** This represents the time it takes to perform each treatment according to validated BDA Heathrow timings and panel inquiry. The timings are specific to either child or an adult. Presented in section 8.2.8 in **Table 8-4**
- iii. **DENTASSim Stage 3 – Age-specific delegation rates by treatment:** These data are derived from UPDA pattern of delegation/skill mix. Presented in section 8.2.9 and **Table 8-5**.
- iv. **DENTASSim Stage 4 – Human resource average national staff working hours:** This was applied to overall clinical hours to ascertain the WTE that would be needed.8.2.10

To follow is the explanation of the model build up presented from section 8.2.6

### **8.2.6 Model Stages**

This section provides details of each of the model stages and outlines the role of the stage in the overall model.

### **8.2.7 DENTASSim stage 1: NHS year 2011/12 age-specific NHS demand for dental service**

The NHSBSA dental demand data for England for the year 2011/12 were used to represent national treatment demand in the model. The data comprised 17 treatment groups. These were procedures under the responsibility of general dental practitioners with performer numbers and contracts with the NHS, for the year 2011/12. Vocational dental training and orthodontic treatments data were excluded. The former means that it is a slight under-representation of primary dental care demand.

The NHS BSA data (NHS Business Service Authority, 2013), revealed that just over 25 million (n=25,989,678) patients had been seen in 24 months prior to April 2012, which was the end of the NHS year 2011/12. Over 30 million examinations were undertaken during this year which involved a total of 78 million (78,434,506) clinical items of care; which was used in the demand stage of the DENTASSim. The full data used in the model are shown in **Table 8-2**.

**Table 8-2 DENTASSim stage 1: NHS B data [2011/12] - demand for dental services in England**

Age-group:	Exams	Scaling & polish	Fluoride varnish	Fissure sealants	Restoration	Endodontics	Extraction	Upper Denture Acrylic	Upper Denture Metal	Lower Denture Metal	Lower Denture Acrylic	Veneer	Inlays	X-rays	bridges	crowns	Antibiotic prescription
0 - 2	624,671	5,358	20,818	440	9,615	24	4,457	41	-	-	16	3	9	894	4	29	1,132
3-5	1,570,807	29,163	229,920	5,540	368,310	910	82,583	132	2	-	17	5	15	15,143	2	397	11,312
6-12	4,174,238	310,623	778,665	167,128	1,866,807	8,701	505,413	888	71	8	150	317	923	249,697	242	1,512	35,856
13 - 17	2,654,901	540,109	321,223	84,216	1,181,705	28,522	309,596	2,682	290	53	540	3,013	9,878	683,751	5,390	11,224	20,594
18 - 24	1,967,316	966,698	62,513	15,706	1,150,435	61,652	186,343	9,733	935	225	2,651	4,161	18,541	1,235,523	8,759	31,325	71,011
25 - 34	3,202,957	1,793,785	78,526	9,932	1,855,566	117,843	391,702	33,559	3,362	1,225	14,010	7,044	45,920	2,136,343	23,263	92,703	109,431
35 - 44	3,992,443	2,376,963	81,760	5,539	1,943,315	123,674	480,359	71,472	6,965	2,973	33,108	7,151	49,494	2,288,292	37,569	148,547	102,288
45 - 54	4,077,298	2,518,549	81,710	3,250	1,992,976	123,474	623,292	115,591	11,283	5,233	58,449	5,367	38,722	2,169,451	44,670	191,867	103,561
55 - 64	3,559,037	2,202,695	68,295	2,388	1,715,589	87,957	563,518	133,745	13,131	6,744	79,549	3,304	21,750	1,527,106	37,277	168,273	75,705
65 - 74	2,684,788	1,582,325	50,166	2,039	1,264,304	51,055	408,937	123,915	11,349	6,650	84,900	1,850	10,022	846,260	22,830	104,467	46,325
75+	1,657,378	840,021	33,884	1,251	803,322	22,586	282,060	112,687	7,899	5,241	90,150	1,007	3,789	358,128	10,185	44,140	24,485
Total	30,165,834	13,166,289	1,807,480	297,429	14,151,944	626,398	3,838,260	604,445	55,287	28,352	363,540	33,222	199,063	11,510,588	190,191	794,484	601,700

Source: NHS BSA 2011/12

Note:1. Each number represents an individual treatment item

## 8.2.8 DENTASSim Stage 2: Treatment time

Stage two represents the timing section of the model. Time in the model is expressed in minutes required to carry out a single treatment. The timings were obtained from BDA Heathrow timings (Bearne and Kravitz, 2000), which were checked for face validity. For three treatments a panel inquiry was undertaken with dentists in NHS settings, because these treatments had not been timed in the BDA inquiry in 1999 [Section 4.6.5.2]. The panel all confirmed that the Heathrow timings were still valid. Some suggested that non-clinical tasks and infection control procedures may account for more time than it did in the past. The results of the panel inquiry and Heathrow BDA timings are in **Table 8-3**. **Table 8-4** follows with all the age-specific timings as presented in stage 2 of the model.

**Table 8-3 Panel inquiry timing results and BDA Heathrow timings**

Treatment	BDA Heathrow timings final times		Panel timing For treatments missing from BDA timings	
	Final timings for adults	Final timings for children	Adult	child
Examinations	11.3		-	-
Scale and polish	15.1		-	-
Fluoride varnish			<b>4</b>	<b>5</b>
Fissure sealants	18.2		-	-
Endodontics	75.7			
Tooth restorations	19.7	17.6	-	-
Extractions	17.6	17.5	-	-
Upper denture acrylic	76.4		-	-
Upper denture metal	79.1		-	-
Lower denture metal	79.1		-	-
Lower denture acrylic	76.4		-	-
Veneers	50.5		--	-
Inlays			-	-
Radiographs			<b>5</b>	<b>5</b>
Bridge units			-	-
Crowns	63.7		-	-
Antibiotic Prescribing			<b>4</b>	<b>4</b>

NOTE: Source: BDA Heathrow timings: panel inquiry treatments in bold: children timings are different



**Table 8-4 DENTASSim stage 2: Age-specific BDA Heathrow timings [1999] & panel inquiry- age-specific, treatment-specific treatment times**

Treatment time in minutes																	
Age-group:	Exams	Scaling & polish	Fluoride varnish	Fissure sealants	Restoration	Endodontics	Extraction	Upper Denture Acrylic	Upper Denture Metal	Lower Denture Metal	Lower Denture Acrylic	Veneer	Inlays	X-rays	bridges	crowns	Antibiotic prescription
0 - 2	11.3	15.1	5	18.2	17.6	75.7	17.5	76.4	79.1	79.1	76.4	50.5	50.5	5	63.7	63.7	4
3 - 5	11.3	15.1	5	18.2	17.6	75.7	17.5	76.4	79.1	79.1	76.4	50.5	50.5	5	63.7	63.7	4
6 - 12	11.3	15.1	5	18.2	17.6	75.7	17.5	76.4	79.1	79.1	76.4	50.5	50.5	5	63.7	63.7	4
13 - 17	11.3	15.1	5	18.2	19.7	75.7	17.6	76.4	79.1	79.1	76.4	50.5	50.5	5	63.7	63.7	4
18 - 24	11.3	15.1	4	18.2	19.7	75.7	17.6	76.4	79.1	79.1	76.4	50.5	50.5	5	63.7	63.7	4
25 - 34	11.3	15.1	4	18.2	19.7	75.7	17.6	76.4	79.1	79.1	76.4	50.5	50.5	5	63.7	63.7	4
35 - 44	11.3	15.1	4	18.2	19.7	75.7	17.6	76.4	79.1	79.1	76.4	50.5	50.5	5	63.7	63.7	4
45 - 54	11.3	15.1	4	18.2	19.7	75.7	17.6	76.4	79.1	79.1	76.4	50.5	50.5	5	63.7	63.7	4
55 - 64	11.3	15.1	4	18.2	19.7	75.7	17.6	76.4	79.1	79.1	76.4	50.5	50.5	5	63.7	63.7	4
65 - 74	11.3	15.1	4	18.2	19.7	75.7	17.6	76.4	79.1	79.1	76.4	50.5	50.5	5	63.7	63.7	4
75+	11.3	15.1	4	18.2	19.7	75.7	17.6	76.4	79.1	79.1	76.4	50.5	50.5	5	63.7	63.7	4

Note: Time in minutes,

Sources:

BDA Heathrow timings [1999]

Panel inquiry and literature: for fluoride varnish, radiographs and antibiotic prescribing timings

### 8.2.9 DENTASSIM Stage 3: Age-specific delegation rates

The third stage in the model was the age-specific and treatment specific rate of delegation of treatment to HTS, as established from the data in UPDA. This part of the model facilitated the simulation of distribution of workload between hygiene-therapist and dentist according to the UPDA model or alternative scenarios providing clinical time and WTE required for the two professional groups. **Table 8-5** shows the age-specific rate at which dentists performed treatments after delegation. Where a procedure was only within the remit of the dentist, 100% of the dentists' time is indicated in the **Table 8-5**. For 'scale and polish' and 'fluoride varnish', an overall delegation rate of 91% was applied for scale and polish and 92% for fluoride varnish because there was little variation in intergroup delegation rate. In the model, this is represented as 9% and 8% of dentist time on these procedures respectively.

**Table 8-5 DENTASSim stage 3: Application of UPDA age-specific treatment-specific delegation rates**

Delegation rate Portsmouth																	
Treatments undertaken by dentist according to Portsmouth Academy by %																	
Age-group:	Exams	Scaling & polish	Fluoride varnish	Fissure sealants	Resto-ration	Endodontics	Tooth extraction	Upper Denture Acrylic	Upper Denture Metal	Lower Denture Metal	Lower Denture Acrylic	Veneer	Inlays	X-rays	bridges	crowns	Antibio Pres
<b>0 - 2</b>	0%	8%	9%	0%	7%	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
<b>3 - 5</b>	0%	8%	9%	2%	11%	0%	44%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
<b>6 -12</b>	0%	8%	9%	10%	16%	0%	80%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
<b>13 - 17</b>	0%	8%	9%	11%	38%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
<b>18 - 24</b>	0%	8%	9%	5%	44%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
<b>25 - 34</b>	0%	8%	9%	14%	45%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
<b>35 - 44</b>	0%	8%	9%	17%	53%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
<b>45 - 54</b>	0%	8%	9%	33%	68%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
<b>55 - 64</b>	0%	8%	9%	0%	61%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
<b>65 - 74</b>	0%	8%	9%	100%	53%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
<b>75+</b>	0%	8%	9%	100%	63%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: University of Portsmouth Dental Academy patient management data

Note: Antibio- pres- Antibiotic prescription

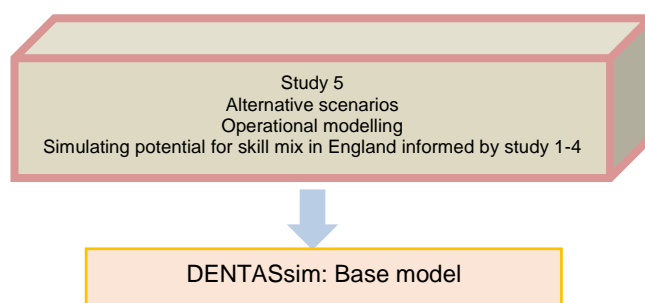
#### **8.2.10 DENTASSim Stage 4: average national weekly hours and annual leave**

Average weekly hours and average annual leave plus estimated part-year working arrangements were included in the last stage of the model in order to provide the WTE. The full time working was listed at 37.5 hours a week and the part-time working arrangements were estimated at 22% for hygiene-therapists and 25% for dentists. These figures were based on previously used workforce times but can be altered depending on the working arrangements being investigated.

Following the outlined fully staged model, scenarios could be simulated by altering various parameters on DENTASSim. In the next section the base outputs of the model are presented. This outlines clinical hours and proportion of clinical time for each treatment based on simulation of national demand and BDA Heathrow timings. These outputs are produced prior to application of stages 3 and 4 of the model.

### 8.3 DENTASSim base model outputs

The base model shows the amount of clinical time in hours that would be spent on each treatment and age group without considering personnel or working hours. The base model provided an understanding of where the bulk of clinical time is spent based on the current demand. The outputs are presented first according to treatment followed by age groups.



**Figure 8-4 Scenarios – base model outputs**

#### 8.3.1 DENTASSim base model outputs: clinical hours by treatment type

First outputs presented are the base model clinical hours by treatment presented in

**Table 8-6.** This shows the overall clinical time requirement for all the treatment demand in England in 2011/12, based on the timings in stage 2 of the model [section 8.2.8].

**Table 8-6 DENTASSim base model results – proportion of total clinical time per treatment**

Treatment	%of all clinical hours	Clinical hours
<b>Examinations</b>	29.4%	5,681,232
<b>tooth restoration</b>	23.7%	4,567,989
<b>Scale And Polish</b>	17.2%	3,313,516
<b>Tooth Extractions</b>	5.8%	1,124,902
<b>Radiographs taken</b>	5.0%	959,216
<b>Crowns</b>	4.4%	843,477
<b>Endodontic Treatment</b>	4.1%	790,306
<b>Upper Denture Acrylic</b>	4.0%	769,660
<b>Lower Denture Acrylic</b>	2.4%	462,908
<b>Bridge units</b>	1.0%	201,919
<b>Inlays</b>	0.9%	167,545
<b>Fluoride Varnish</b>	0.7%	143,009
<b>Fissure Sealants</b>	0.5%	902,20.
<b>Upper Denture Metal</b>	0.4%	72,887
<b>Antibiotic Items Prescribed</b>	0.2%	40,113
<b>Lower Denture Metal</b>	0.2%	37,377
<b>Veneers Applied</b>	0.1%	27,962
<b>Total</b>	100%	19,294,238

From

**Table 8-6** outputs, it is apparent that the total number of clinical hours required to meet all the demand for dental care nationally was 19, 294,238. The highest proportion of clinical hours was taken up by examinations; 5,681,232 (29.4%) and lowest was veneers at 27,962 (0.1%).

If these procedures are grouped further into 5 categories: diagnostic, complex, medium complexity, preventative and other, the results would show that diagnostic treatments represented the highest proportion of clinical time (34%). Details are shown in

**Table 8-7.**

**Table 8-7 DENTASSim base model results - grouped treatments according to complexity**

Treatment group		Percentage of all clinical hours	Treatment group Percentage of all clinical hours
Diagnostic	Examinations	29.4%	34.4%
	Radiographs	5.0%	
Medium complexity	Tooth restoration	23.7%	24.8%
	Paediatric tooth extraction	1%	
	Paediatric endodontics	0.1%	
Complex treatments	Adult tooth extractions	4.8%	22.2%
	Crowns	4.4%	
	Endodontic Treatment	4.1%	
	Upper Denture Acrylic	4.0%	
	Lower Denture Acrylic	2.4%	
	Bridge units	1.0%	
	Inlays	0.9%	
	Upper Denture Metal	0.4%	
	Lower Denture Metal	0.2%	
	Veneers Applied	0.1%	
Prevention	Scale And Polish	17.2%	18.4%
	Fluoride Varnish	0.7%	
	Fissure Sealants	0.5%	
Other	Antibiotic Items Prescribed	0.2%	0.2%

**Note:** Complexity has been based on treatments within the skills of the dentists only.

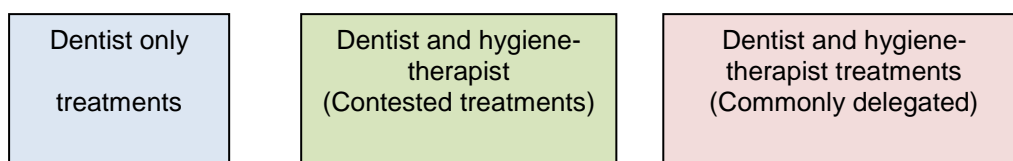


Table 8-7 showed that diagnostic procedures take the most clinical time. Medium complexity treatments, which both dentists and hygiene-therapists can undertake, were the second most time consuming treatments. These are also marked as green- indicating they are the contested treatments when delegation is considered. Prevention treatments commonly undertaken by DCPs constituted 18.4% of the clinical time. The model suggests that the total clinical time that could be undertaken by dentists is 100%, while 77.6% of clinical time can be undertaken by hygiene-therapists.

### 8.3.2 DENTASSim base model outputs; clinical hours by age group

Age-specific clinical time for treatment are shown in **Table 8-8** and the findings suggest that the 45-54 year old age group had the most clinical time assigned to them (16.2%), while the 0-2 years (0.6%) and the 3-5 years (2.4%) required the least amount of clinical time.

**Table 8-8 DENTASSim base model results - total clinical hours to meet demand by age group**

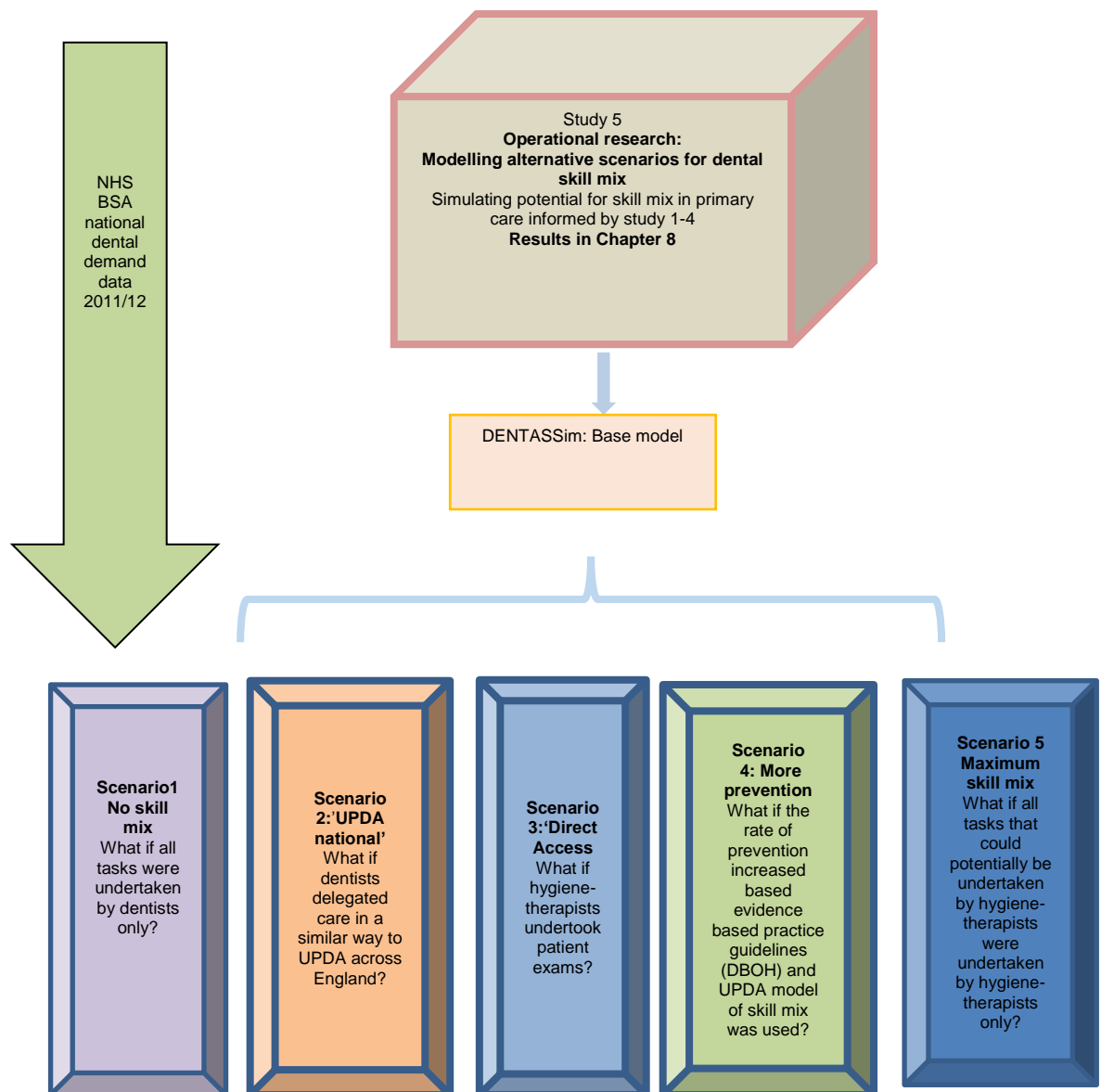
Age groups	Clinical hours	Proportion of total hours
<b>0 - 2yrs</b>	125,281.4	0.6%
<b>3 - 5yrs</b>	459,936.4	2.4%
<b>6 - 12yrs</b>	171,3423	8.9%
<b>13 - 17yrs</b>	129,4437	6.7%
<b>18 - 24yrs</b>	1,319,555	6.8%
<b>25 - 34yrs</b>	2,355,367	12.2%
<b>35 - 44yrs</b>	2,881,285	14.9%
<b>45 - 54yrs</b>	3,120,443	16.2%
<b>55 - 64yrs</b>	2,738,878	14.2%
<b>65 - 74yrs</b>	2,015,668	10.4%
<b>75+yrs</b>	1,269,964	6.6%
<b>total hours</b>	19,294,238	

Sources: findings results of BDA Heathrow timings and NHS BSA England data on dental demand

In the next section the results of the scenario simulations are reported.

## 8.4 Scenarios and outputs

Scenarios were informed by UPDA analysis, literature review of contemporary NHS regulation, and changing needs. The five ‘what if’ scenarios, developed for simulation on DENTASSim **Figure 8-5** is an overview of each scenario; the scenario development methods were detailed in Section 4.6.5



**Figure 8-5 Overview of scenarios**



The developed model, DENTASSim, provides outputs in the form of total clinical time for each treatment and age group, and total WTE for dentists and hygiene-therapists depending on the scenario. These outputs are based on the total demand for care experienced in the NHS year 2011/12. If stage 3 [delegation rates] and stage 4 [working time], of DENTASSim are not simulated the outputs can be described as the base model outputs which were presented in Section 8.3

In the subsequent sections scenario outputs are reported as follows:

- i. **Scenario 1: 'No skill mix'**- the total clinical hours for dentists are shown for each age group and treatment group. Followed by WTE of dentists required. See Section 8.4.2.
- ii. **Scenario 2: 'UPDA national'** outputs are presented as clinical time for treatment items and age groups. This is followed by the calculated whole time equivalents [WTE] for each professional required to meet demand. See Section 8.4.3.3 and 8.4.3.4.
- iii. **Scenario 3: 'Direct Access'** outputs are presented by clinical time for treatment items and age groups. The WTE for the varied direct access simulations are then shown. See Section 8.4.4.1 and 8.4.4.2.
- iv. **Scenario 4: 'More prevention'** outputs are reported by children's age group changes in clinical time for dentist and hygiene-therapists. This is followed by the calculated WTE for each version of scenario 4 for dentists and hygiene-therapists. See Section 8.4.5.1 and 8.4.5.2.
- v. **Scenario 5: 'Maximum skill mix'** outputs are presented as clinical time for treatment items and age groups. This is followed by the calculated whole time equivalents [WTE] for each professional required to meet demand See Section 8.4.6.1.

#### 8.4.1 Scenario 1: No skill mix

Scenario 1 described in section 4.6.5.3 is a situation where all the clinical hours will be undertaken by dentists. This output will be similar to the base model; but solely assigned to dentists. The model will show the expected WTE based on the models dentists working hours and annual leave arrangement times (stage 5 of model)

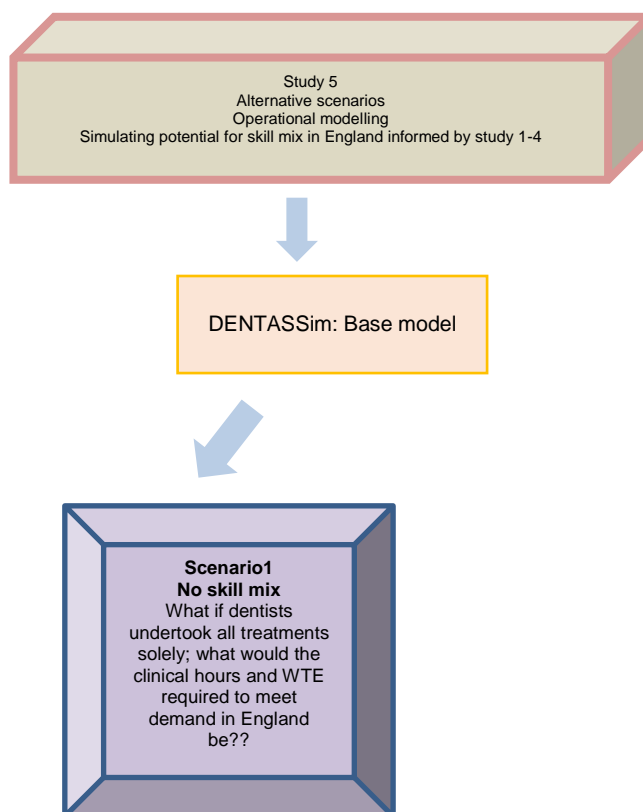


Figure 8-6 Scenario 2 ' No skill mix'

#### 8.4.2 DENTASSim scenario 1 outputs 'No skill mix' Clinical hours by treatment type and WTE

Following simulation of scenario 1, where No skill mix is modelled on England's demand the output would be as presented in **Table 8-9** which are the same outputs as the base model, however in this scenario all the clinical hours are undertaken by dentists only

**Table 8-9 Scenario 1 'No skill mix' outputs on clinical hours**

Treatment	% of all clinical hours	Dentists Clinical hours
Examinations	29.4%	5,681,232
tooth restoration	23.7%	4,567,989
Scale And Polish	17.2%	3,313,516
Tooth Extractions	5.8%	1,124,902
Radiographs	5.0%	959,216
Crowns	4.4%	843,477
Endodontic Treatment	4.1%	790,306
Upper Denture Acrylic	4.0%	769,660
Lower Denture Acrylic	2.4%	462,908
Bridge units	1.1%	201,919
Inlays	0.9%	167,545
Fluoride Varnish	0.7%	143,009
Fissure Sealants	0.5%	902,20.
Upper Denture Metal	0.4%	72,887
Antibiotic Items Prescribed	0.2%	40,113
Lower Denture Metal	0.2%	37,377
Veneers Applied	0.1%	27,962
Total	100%	19,294,238

##### 8.4.2.1 DENTASSim scenario 1 outputs 'No skill mix' Whole time equivalent

The scenario further assigns the total whole time equivalent expected in this scenario, based on working patterns of dentists as input into the model stage 5. The findings of the WTE simulation suggest that **12,685 WTE** would be required with to meet the demand for dental services that was experienced in England in 2011/12.

### 8.4.3 DENTASSim Scenario 2: Applying the UPDA model nationally

This scenario models the national demand for dental treatment in England during 2011/12 NHS year in DENTASSim and delegation rate applied as established from UPDA data analysis. This is followed by a simulation of required clinical hours and WTE for dentist and hygiene-therapists, if UPDA model of practice was adopted nationally.

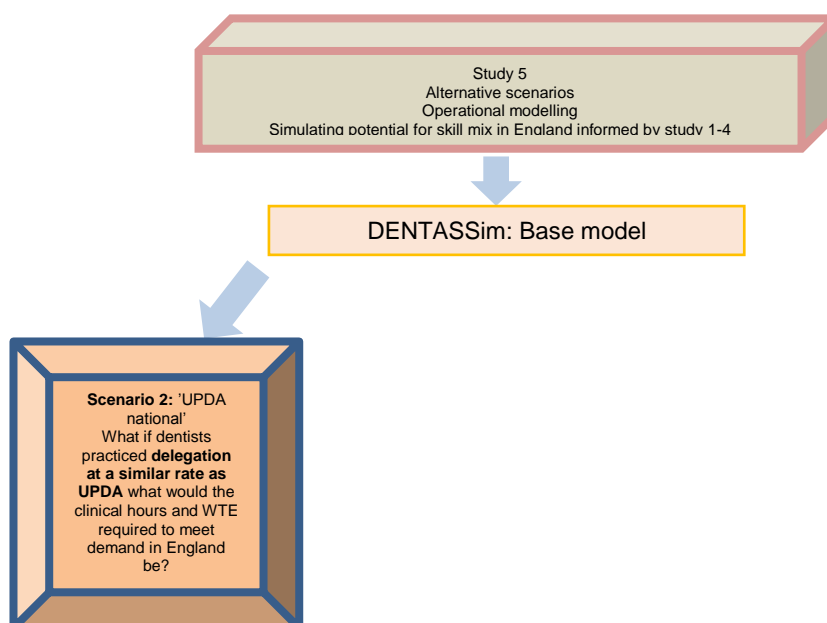


Figure 8-7 Alternative scenarios - Scenario2

#### 8.4.3.1 Scenario 2 results

**Table 8-10** and **Table 8-11** below show the 'UPDA national' scenario outputs following the simulation of clinical hours for dentists and hygiene-therapists by age group for each treatment. The former represents dentists and the latter hygiene-therapists.

**Table 8-10 DENTASSim scenario 2 results: Treatment hours for dentists following simulation**

Treatment Hours for dentists following scenario 2																	
Age-group:	Exams	Scaling & polish	Fluoride varnish	Fissure sealants	Tooth Restoration	Endodontics	Extraction	Upper Denture Acrylic	Upper Denture Metal	Lower Denture Metal	Lower Denture Acrylic	Veneer	Inlays	X-rays	bridges	crowns	Antibiotic prescript
0 - 2	117,646	108	156	0	197	0	0	52	0	0	20	3	8	75	4	31	75
3-6	295,835	587	1,724	29	11,884	0	10,598	168	3	0	22	4	13	1,262	2	421	754
6-12	786,148	6,254	5,840	4,917	87615	0	117,930	1131	94	11	191	267	777	20,808	257	1,605	2,390
13 - 17	500,006	10874	2,409	2,887	147,437	35,985	90,815	3,415	382	70	688	2,536	8,314	56,979	5,722	11,916	1,373
18 - 24	370,511	19,463	375	243	166,200	77,784	53,567	12,393	1,233	297	3,376	3,502	15,605	102,960	9,299	33,257	4,734
25 - 34	603,224	36115	471	410	274,160	148,679	114,899	42,732	4,432	1,615	17,839	5,929	38,649	178,029	24,698	98,420	7,295
35 - 44	751,910	47,856	491	281	338,169	156,035	140905	91,008	9,182	3,919	42,158	6,019	41,657	190,691	39,886	157,707	6,819
45 - 54	767,891	50707	490	328	444965	155,783	182,832	147186	14,875	6,899	74,425	4,517	32,591	180,788	47,425	203,699	6,904
55 - 64	67,0285	44,348	410	0	343,604	11,0972	165,299	170,302	17,311	8,891	101,292	2781	18,306	127,259	39,576	178650	5,047
65 - 74	50,5635	31,857	301	619	220,010	64,414	119,955	157,785	14,962	8,767	108,106	1,557	8,435	70,522	24,238	110,909	3,088
75+	312140	16,912	203	379	166167	28,496	82,738	143,488	10,414	6,909	11,4791	848	3,189	29,844	10,813	46,862	1632
<b>Total</b>	<b>5,681,232</b>	<b>265,081</b>	<b>12,871</b>	<b>10,092</b>	<b>2,200,409</b>	<b>778,149</b>	<b>1,079,538</b>	<b>769,660</b>	<b>72,887</b>	<b>37,377</b>	<b>462,908</b>	<b>27,962</b>	<b>167,545</b>	<b>959,216</b>	<b>201,919</b>	<b>843,477</b>	<b>40,113</b>

Source: NHS BSA England demand for treatment 2011/12, UPDA delegation rates and BDA Heathrow timings

**Table 8-11 11 DENTASSim scenario 2 results - treatment hours for hygiene-therapists following simulation**

Age-group:	Exams	Scaling & polish	Fluoride varnish	Fissure sealants	Restoration	Endodontics	Extraction	Upper Denture Acrylic	Upper Denture Metal	Lower Denture Metal	Lower Denture Acrylic	Veneer	Inlays	X-rays	bridges	crowns	Antibiotic prescript
<b>0 - 2</b>	0	1,241	1,579	133	2,623	30	1,300	0	0	0	0	0	0	0	0	0	0
<b>3-5</b>	0	6,752	17,436	1,652	96,153	1,148	13,489	0	0	0	0	0	0	0	0	0	0
<b>6-12</b>	0	71,920	59,049	45,778	459,981	10,978	29,482	0	0	0	0	0	0	0	0	0	0
<b>13 - 17</b>	0	125,053	24,359	22,659	240,556	0	0	0	0	0	0	0	0	0	0	0	0
<b>18 - 24</b>	0	223,823	3,792	4,521	211,527	0	1,093	0	0	0	0	0	0	0	0	0	0
<b>25 - 34</b>	0	415,321	4,764	2,603	335,084	0	0	0	0	0	0	0	0	0	0	0	0
<b>35 - 44</b>	0	550,346	4,960	1,400	299,886	0	0	0	0	0	0	0	0	0	0	0	0
<b>45 - 54</b>	0	583,128	4,957	658	209,395	0	0	0	0	0	0	0	0	0	0	0	0
<b>55 - 64</b>	0	509,997	4,143	724	219,681	0	0	0	0	0	0	0	0	0	0	0	0
<b>65 - 74</b>	0	366,361	3,043	0	195,103	0	0	0	0	0	0	0	0	0	0	0	0
<b>75+</b>	0	194,493	2,056	0	97,590	0	0	0	0	0	0	0	0	0	0	0	0
<b>Total</b>	0	3,048,435	130,138	80,128	2,367,580	12,156	45,364	0	0	0	0	0	0	0	0	0	0

Source: NHS BSA England demand for treatment 2011/12, UPDA delegation rates and BDA Heathrow timings

#### 8.4.3.2 DENTASSim scenario 2 outputs 'UPDA national' Clinical hours by treatment type

Following simulation of scenario 2, where UPDA's delegation rate is modelled on England's demand. **Table 8-12** describes the clinical hours for shared treatments.

**Table 8-12 Scenario 2 'UPDA national' outputs on clinical hours by profession per treatment**

Treatment	% of all clinical hours	Clinical hours	Dentist hours	Dentists % of all clinical hours	Hygiene-therapist hours	Hygiene-therapist % of all clinical hours
Examinations	29.4%	5,681,232	5,681,232	29.4%	0	0.0%
Tooth restoration	23.7%	4,567,989	2,200,409	11.4%	2,367,580	12.3%
Scale and Polish	17.2%	3,313,516	265,081	1.4%	3,048,435	15.8%
Tooth Extractions	5.8%	1,124,902	1,079,538	5.6%	45,364	0.2%
Radiographs	5.0%	959,216	959,216	5.0%	0	0.0%
Crowns	4.4%	843,477	843,477	4.4%	0	0.0%
Endodontic Treatment	4.1%	790,306	778,149	4.0%	12,156	0.1%
Upper Denture Acrylic	4.0%	769,660	769,660	4.0%	0	0.0%
Lower Denture Acrylic	2.4%	462,908	462,908	2.4%	0	0.0%
Bridge units	1.1%	201,919	201,919	1.0%	0	0.0%
Inlays	0.9%	167,545	167,545	0.9%	0	0.0%
Fluoride Varnish	0.7%	143,009	12,871	0.08%	130,138	0.7%
Fissure Sealants	0.5%	902,20.	10,092	0.1%	80,128	0.4%
Upper Denture Metal	0.4%	72,887	72,887	0.4%	0	0.0%
Antibiotic Items Prescribed	0.2%	40,113	40,113	0.2%	0	0.0%
Lower Denture Metal	0.2%	37,377	37,377	0.2%	0	0.0%
Veneers Applied	0.1%	27,962	27,962	0.1%	0	0.0%
<b>Total</b>	<b>100%</b>	<b>19,294,238</b>	<b>13,610,436</b>	<b>70.5%</b>	<b>5,683,801</b>	<b>29.5%</b>

Note: 1. Endodontic treatment is for patients under 12 years only

2. Red column represents age-specific clinical time in hours for hygiene-therapists while blue represents dentists' clinical hours

**Table 8-12** Scenario 2 simulation suggests that the proportion of hours spent on the tasks that could be delegated according to the UPDA skill mix model would constitute 52% of all clinical hours. These included (tooth restorations, scale/polish (17.2%), tooth restorations (23.7%), primary tooth extractions (0.1%), endodontics on primary teeth (0.1%), fluoride varnish (0.7%) and fissure sealants (0.5%). Second, if UPDA delegation rates are applied, 29.5% of all clinical hours would be performed by the hygiene-therapists.

#### 8.4.3.2.1 Scale and polish

The total hours spent on scale and polish for England in 2011/12 would be 3,313,516 hours which is 17.2% of the treatment hours based on scenario 2. If 91% of scale and polish was delegated 15.8% of all treatment hours would be done by hygiene-therapists.

#### 8.4.3.2.2 Tooth restorations

Clinical hours used to perform tooth restorations would amount to 23.7% of all treatment hours, and by applying scenario 2, which has 52% of tooth restorations, would be done by hygiene-therapists, which amounts to 10.8% of all clinical hours.

#### 8.4.3.2.3 Endodontics

Endodontics as a whole account for 4.1% of all the clinical hours, but only pulpotomies, which are endodontic procedures performed on primary teeth can be delegated. Pulpotomies were delegated at 100% with scenario 2, but only represent 0.1% of all clinical hours.

#### 8.4.3.2.4 Tooth extractions

Tooth extractions represent 5.8% of all clinical hours but only 0.2% of the tooth extraction hours would be done by hygiene-therapists based on the delegation rate of scenario 2.

#### 8.4.3.2.5 Fluoride varnish

The total time for fluoride varnish application according to the model was 0.7% and with a delegation rate of 92% in UPDA majority of this time would be undertaken by hygiene-therapists.



#### 8.4.3.3 DENTASSim scenario 2 outputs 'UPDA national' Clinical hours by age group

**Table 8-13** below shows the difference in the proportion of total clinical time for dentist and hygienist sharing tasks within each age group if UPDA's pattern of task delegation is adapted to cope with national demand.

**Table 8-13 DENTASSim scenario 2 clinical hours by age group**

Age groups	Clinical hours	% of total hours	dentist hours	dentist % of all clinical hours	hygiene-therapist hours	hygiene-therapist % of all clinical hours
0 - 2yrs	125,281.40	0.6%	118,375	0.6%	6,906	0.0%
3 - 5yrs	459,936.40	2.4%	323,306	1.7%	136,630	0.7%
6 - 12yrs	1,713,423	8.9%	1,036,235	5.4%	677,188	3.5%
13 - 17yrs	1,294,437	6.7%	881,808	4.6%	412,627	2.1%
18 - 24yrs	1,319,555	6.8%	874,799	4.5%	444,756	2.3%
25 - 34yrs	2,355,367	12.2%	1,597,596	8.3%	757,772	3.9%
35 - 44yrs	2,881,285	14.9%	2,024,693	10.5%	856,592	4.4%
45 - 54yrs	3,120,443	16.2%	2,322,305	12.0%	798,138	4.1%
55 - 64yrs	2,738,878	14.2%	2,004,333	10.4%	734,545	3.8%
65 - 74yrs	2,015,668	10.4%	1,451,160	7.5%	564,507	2.9%
75+yrs	1,269,964	6.6%	975,825	5.1%	294,139	1.5%
<b>total hours</b>	<b>19,294,238</b>	<b>100%</b>	<b>13,610,436</b>	<b>70.5%</b>	<b>5,683,801</b>	<b>29.5%</b>

Note: Red column represents age-specific clinical time in hours for hygiene-therapists while blue represents dentists' clinical hours and white is the base model overall clinical hours

Table 8-13 has demonstrated that the demand within each age group has a significant influence on the proportion of clinical time that can be saved by delegation. An example can be shown by the patients over the age of 75 years according to 'UPDA model of delegation' shown in stage 3 of the model [see section 8.2.9] is 63% of tooth restorations to hygiene-therapists; however, from **Table 8-13** it is evident that there is still a high proportion of clinical time outside the remit of hygiene-therapists as only 1.5% of the total clinical time is handled by hygiene-therapists in this scenario compared with 5.1% for dentists, even with such a higher rate of tooth restoration delegation.

#### 8.4.3.4 DENTASSim scenario 2 outputs 'UPDA national' Whole time equivalent

The clinical hours shown were converted to whole time equivalents as the fourth stage of DENTASSim'. The result is that 8,948 WTE dentists and 3,886 WTE hygiene-therapists would

be required with 'UPDA nations' scenarios. This translated to a total of 12,835 WTE dental professionals working at similar rates of time to meet the demand for dental services that was experienced in England in 2011/12.

#### 8.4.4 DENTASSim Scenario 3: 'Direct Access'

This scenario is based on the new direct access regulation (General Dental Council 2013a). As detailed in section 4.6.5.3. Scenario 3 involved 10 simulations, which can be viewed as 10 sub-scenarios; of 10% varying rate of examination delegation between 0% delegation to 100%. The outputs give an indication of the impact of each variation on skill mix. The model still includes the delegation practices/skill mix model for all other procedures. At each simulation that alters the proportion of examinations undertaken by hygiene-therapists the clinical time and WTE for dentists and hygiene-therapists is noted for changes.

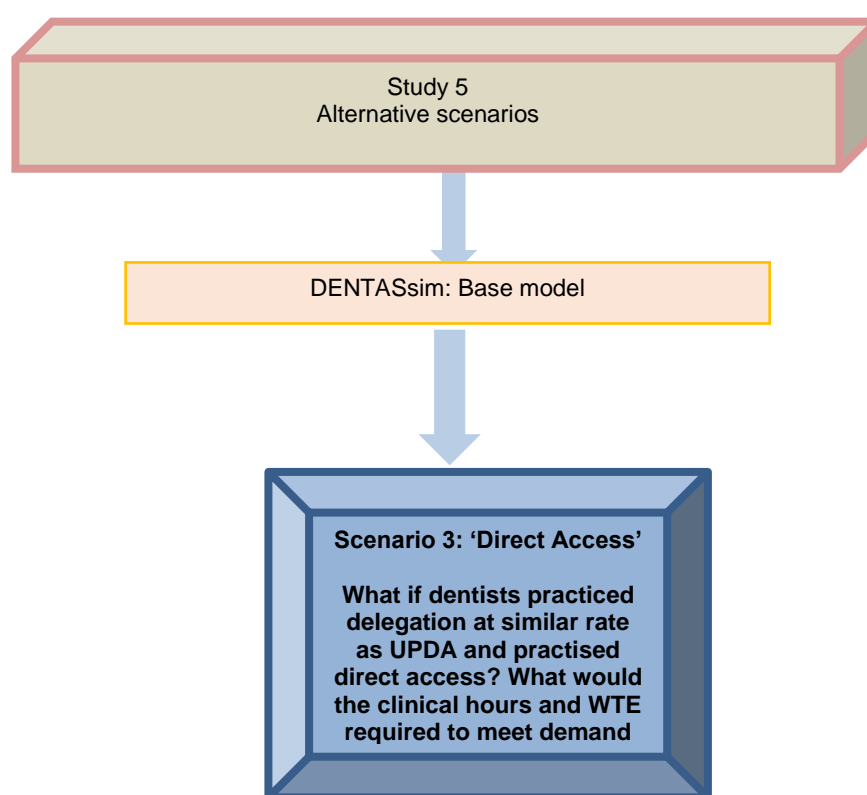


Figure 8-8 Scenario 3 diagram

#### **8.4.4.1 DENTASSim scenario 3 outputs - Clinical hours**

After simulating 10 different direct access sub-scenarios, which varied the proportion of examinations done by either a dentist or hygiene-therapist, the results showed that if the delegation rate of UPDA's model was maintained for all other treatments other than examinations, and hygiene-therapist performed examinations at varied proportions, at 70% DA (70% of assessments by hygiene-therapists), the number of clinical hours performed by dentists and hygiene-therapists would be equal. See **Table 8-14**. At 30% DA, both hygiene-therapists would have higher total clinical hours than dentists among the 3-5 year olds and 6-12 year olds.

**Table 8-14 DENTASSim scenario 3 results - varied direct access (DA) % of exams undertaken by hygiene-therapist and resultant clinical hours**

	0%		10%		20%		30%		40%		50%		60%		70%		80%		90%		100%	
	DA		DA		DA		DA		DA		DA		DA		DA		DA		DA		%DA	
Age-group:	D	HT	D	HT	D	HT	D	HT	D	HT	D	HT	D	HT	D	HT	D	HT	D	HT	D	HT
0 - 2	118,375	6,906	106,611	18,671	94,846	30,435	83,082	42,200	71,317	53,964	59,552	65,729	47,788	77,494	36,023	89,258	24,258	101,023	12,494	112,788	729	124,552
3-5	323,307	136,630	293,723	166,213	264,140	195,797	234,556	225,380	204,972	254,964	175,389	284,548	145,805	314,131	116,222	343,715	86,638	373,298	57,055	402,882	27,471	432,465
6-12	1,036,235	677,188	957,620	755,803	879,005	834,417	800,390	913,032	721,776	991,647	643,161	1,070,262	564,546	1,148,877	485,931	1,227,492	407,316	1,306,106	328,701	1,384,721	250,087	1,463,336
13 - 17	881,809	412,627	831,809	462,628	781,808	512,629	731,807	562,629	681,807	612,630	631,806	662,630	581,806	712,631	531,805	762,632	481,804	812,632	431,804	862,633	381,803	912,634
18 - 24	874,799	444,756	837,748	481,807	800,697	518,859	763,646	555,910	726,595	592,961	689,544	630,012	652,492	667,063	615,441	704,114	578,390	741,165	541,339	778,216	504,288	815,267
25 - 34	1,597,595	757,772	1,537,272	818,095	1,476,950	878,417	1,416,628	938,739	1,356,305	999,062	1,295,983	1,059,384	1,235,661	1,119,706	1,175,338	1,180,029	1,115,016	1,240,351	1,054,693	1,300,673	994,371	1,360,996
35 - 44	2,024,694	856,592	1,949,503	931,783	1,874,312	1,006,974	1,799,121	1,082,165	1,723,930	1,157,356	1,648,739	1,232,547	1,573,548	1,307,738	1,498,357	1,382,929	1,423,166	1,458,120	1,347,975	1,533,311	1,272,784	1,608,502
45 - 54	2,322,305	798,138	2,245,516	874,927	2,168,727	951,716	2,091,937	1,028,505	2,015,148	1,105,294	1,938,359	1,182,084	1,861,570	1,258,873	1,784,781	1,335,662	1,707,992	1,412,451	1,631,203	1,489,240	1,554,414	1,566,029
55 - 64	2,004,332	734,546	1,937,304	801,575	1,870,275	868,603	1,803,247	935,632	1,736,218	1,002,660	1,669,190	1,069,689	1,602,161	1,136,717	1,535,133	1,203,746	1,468,104	1,270,774	1,401,076	1,337,803	1,334,047	1,404,831
65 - 74	1,451,160	564,508	1,400,597	615,071	1,350,033	665,635	1,299,470	716,198	1,248,906	766,762	1,198,343	817,325	1,147,779	867,889	1,097,216	918,452	1,046,652	969,016	996,089	1,019,579	945,525	1,070,143
75+	975,826	294,139	944,612	325,353	913,398	356,567	882,184	387,781	850,970	418,995	819,756	450,208	788,542	481,422	757,328	512,636	726,114	543,850	694,900	575,064	663,686	606,278
Total	13,610,437	5,683,801	13,042,313	6,251,925	12,474,190	6,820,048	11,906,067	7,388,171	11,337,944	7,956,294	10,769,821	8,524,418	10,201,697	9,092,541	9,633,574	9,660,664	9,065,451	10,228,787	8,497,328	10,796,910	7,929,205	11,365,034

Note:

1. D – Dentist; HT- Hygiene-therapist
2. Red column represents age-specific clinical time in hours for hygiene-therapists while blue represents dentists' clinical hours
3. DA% refers to the proportion of assessments undertaken by hygiene-therapists.

An evaluation of the percentage change in total clinical time undertaken by dentists and hygiene-therapists following simulation of different proportions of direct access is presented in **Table 8-15**.

**Table 8-15 DENTASSim scenario 3 'Direct Access' clinical hours by % of assessments undertaken by hygiene-therapists**

% Of examinations undertaken by hygiene-therapists	Proportion of clinical time by dentists for all clinical hours	Dentists total clinical hours	Proportion of clinical time by hygiene-therapists for all clinical hours	Proportion of clinical time hygiene-therapists total clinical hours
0%	70.5%	13,610,437	29.5%	5,683,801
10%	67.6%	13,042,313	32.4%	6,251,925
20%	64.7%	12,474,190	35.3%	6,820,048
30%	61.7%	11,906,067	38.3%	7,388,171
40%	58.8%	11,337,944	41.2%	7,956,294
50%	55.8%	10,769,821	44.2%	8,524,418
60%	52.9%	10,201,697	47.1%	9,092,541
70%	49.9%	9,633,574	50.1%	9,660,664
80%	47.0%	9,065,451	53.0%	10,228,787
90%	44.0%	8,497,328	56.0%	10,796,910
100%	41.1%	7,929,205	58.9%	11,365,034

Note: red column represents age-specific clinical time in hours for hygiene-therapists while blue represents dentists' clinical hours

**Table 8-15** shows that at 70% direct access i.e hygiene-therapists having undertaken 70% of assessments the total clinical time for both dentists and hygiene-therapists will be equal. **Table 8-16** below shows the age-specific change in clinical time and proportion of total clinical time for both professionals in the event of direct access arrangements.

**Table 8-16 DENTASSim scenario 3 'Direct Access' clinical hours by age group**

	0% DA				50% DA				100% DA			
Age	dentist total clinical hours	% of total clinical hours	hygiene- therapist total clinical hours	hygiene- therapist % of total clinical hours	dentist total clinical hours	% of total clinical hours	hygiene- therapist total clinical hours	hygiene- therapist % of total clinical hours	dentist total clinical hours	dentists% of total clinical hours	hygiene- therapists total clinical hours	hygiene- therapist % of total clinical hours
0 - 2	118,375	0.6%	6,906	0.0%	59,552	0.3%	65,729	0.3%	729	0.0%	124,552	0.6%
3- 5 yrs	323,307	1.7%	136,630	0.7%	175,389	0.9%	284,548	1.5%	27,471	0.1%	432,465	2.2%
6-12 yrs	1,036,235	5.4%	677,188	3.5%	643,161	3.3%	1,070,262	5.5%	250,087	1.3%	1,463,336	7.6%
13 - 17	881,809	4.6%	412,627	2.1%	631,806	3.3%	662,630	3.4%	381,803	2.0%	912,634	4.7%
18 - 24	874,799	4.5%	444,756	2.3%	689,544	3.6%	630,012	3.3%	504,288	2.6%	815,267	4.2%
25 - 34	1,597,595	8.3%	757,772	3.9%	1,295,983	6.7%	1,059,384	5.5%	994,371	5.2%	1,360,996	7.1%
35 - 44	2,024,694	10.5%	856,592	4.4%	1,648,739	8.5%	1,232,547	6.4%	1,272,784	6.6%	1,608,502	8.3%
45 - 54	2,322,305	12.0%	798,138	4.1%	1,938,359	10.0%	1,182,084	6.1%	1,554,414	8.1%	1,566,029	8.1%
55 - 64	2,004,332	10.4%	734,546	3.8%	1,669,190	8.7%	1,069,689	5.5%	1,334,047	6.9%	1,404,831	7.3%
65 - 74	1,451,160	7.5%	564,508	2.9%	1,198,343	6.2%	817,325	4.2%	945,525	4.9%	1,070,143	5.5%
75+	975,826	5.1%	294,139	1.5%	819,756	4.2%	450,208	2.3%	663,686	3.4%	606,278	3.1%
Total	13,610,437	70.5%	5683801	29.5%	10769821	55.8%	8524418	44.2%	7929205	41.1%	11365034	58.9%

Note:

1. Red column represents age-specific clinical time in hours for hygiene-therapists while blue represents dentists' clinical hours
2. DA refers to direct access

#### 8.4.4.2 DENTASSim scenario 3 'Direct Access' - Whole time equivalents

With every simulation of 'direct access's the WTE for both dentists and hygiene-therapists changed as shown in **Table 8-17**. At 80% direct access the number of WTE hygiene-therapists required would exceed the number of dentists. The findings suggest that a near ratio of 1:1 for dentists to hygiene-therapist would occur with 70% direct access.

**Table 8-17 Direct access at varied proportions and WTE for dentist and hygiene-therapists**

% of examinations undertaken by hygiene-therapists	WTE Dentist	WTE hygiene-therapist
0%	8,948	3,886
10%	8,575	4,275
20%	8,201	4,663
30%	7,828	5,052
40%	7,454	5,440
50%	7,081	5,829
60%	6,707	6,217
70%	6,334	6,606
80%	5,960	6,994
90%	5,587	7,383
100%	5,213	7,771

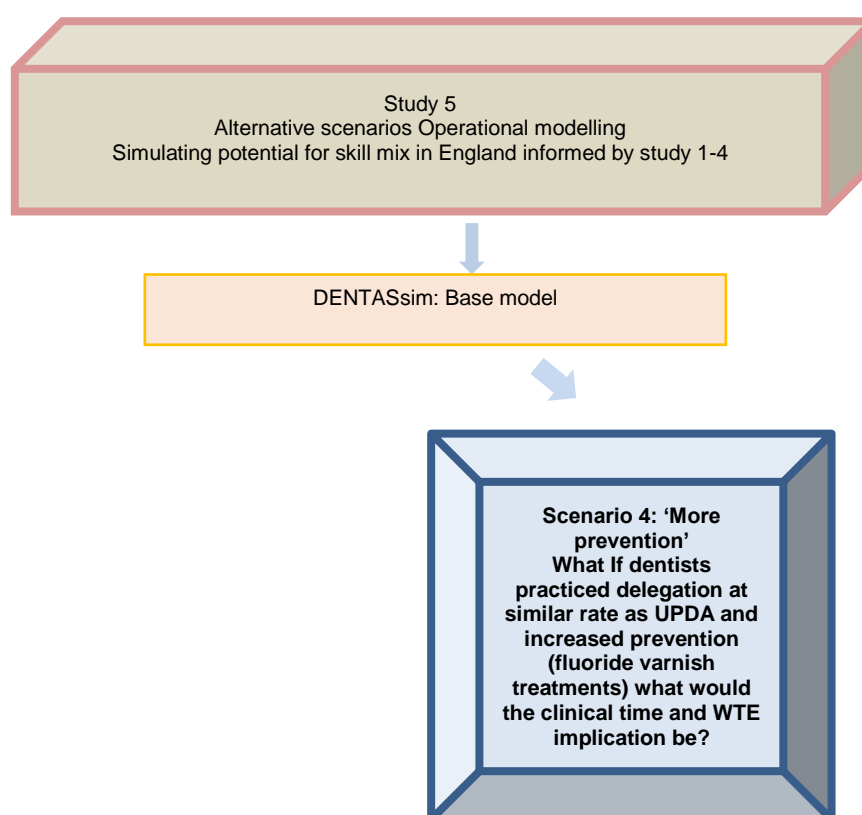
Note:

1. This is the total WTE for all demand
2. The other procedures apart from exams are delegated at the UPDA rate.
- 3: Red column represents age-specific clinical time in hours for hygiene-therapists while blue represents dentists' clinical hours



#### 8.4.5 DENTASSim Scenario 4: 'More prevention'

Scenario 4 simulated the impact of an improvement in the provision of preventative care. As detailed in section 4.6.5.3. This scenario simulated changes in the proportion of fluoride varnish treatments. For the NHS year in focus 2011/12, 13.1% of children's treatment plans included fluoride varnish (Health and Social Care Information Centre, 2012). The scenario also maintains the delegation rate of 92% from UPDA study. In scenario 4, 8 simulations were run each varying increases in the proportions of fluoride varnishes from between 20% to 100%. In the next section the outputs from each of the scenario simulations are presented.



**Figure 8-9 Scenarios output scenario 4 'more prevention'**

Before simulating scenario 4, the increase in demand for prevention had to be calculated this is shown in **Table 8-18**.

**Table 8-18 Scenario building: Simulation of increase in demand of fluoride varnish for scenario 4**

Fluoride varnish numbers by age group	0-2 yrs	3-5yrs	6-12yrs	13-17yrs
<b>Base</b>	<b>20,818</b>	<b>229,920</b>	<b>778,665</b>	<b>321,223</b>
<b>Sim:20%</b>	31,783	351,023	1,188,802	490,417
<b>Sim:30%</b>	47,675	526,534	1,783,202	735,625
<b>Sim:40%</b>	63,567	702,045	12,377,603	980,833
<b>Sim:50%</b>	79,458	877,557	2,972,004	1,226,042
<b>Sim:60%</b>	95,350	1,053,069	3,566,405	1,471,250
<b>Sim:70%</b>	111,241	1,228,580	4,160,805	1,716,459
<b>Sim:80%</b>	127,133	1,404,092	4,755,206	1,961,667
<b>Sim:90%</b>	143,024	1,579,603	5,349,607	2,206,876
<b>Sim:100%</b>	158,916	1,755,115	5,944,008	2,452,084

Note:

- i. Sim refers to simulation percentage
- ii. Base represents England 2011/12 demand for fluoride varnish in children which was 13.1% of all children's treatment plans

#### **8.4.5.1 DENTASSim scenario 4 'more preventions' outputs: change in total clinical hours**

The overall clinical hours would increase if fluoride varnish is/were to be performed at a higher rate. If the proportion of fluoride varnish treatments increased from the baseline 13.1% rate of fluoride varnish in children's treatment plans to 100%, there would be 746,625 more clinical hours, which is a 4% increase in total clinical time. This assumes the same rate of delegation as UPDA (91%) is maintained, and all children treatment plans involve fluoride varnish, for dentists the increase in number of clinical hours would be 67,196 hours, compared with 679,429 hours for hygiene-therapists. **Table 8-19** shows the clinical hour changes for the two professions for children's age groups.

**Table 8-19 DENTASSim Scenario 4 ‘more preventions’ outputs: Clinical hours for dentists and hygiene-therapists if fluoride varnish treatments are increased in children from 13% to 100%**

**Clinical hours for dentists and hygiene-therapists following alteration of proportion of fluoride varnish treatments**

	13.1% base		20%		30%		40%		50%		60%		70%		80%		90%		100%	
Age-group: in years	dentist	hygiene-therapist	dentist	hygiene-therapist	dentist	hygiene-therapist	dentist	hygiene-therapist	dentist	hygiene-therapist	dentist	hygiene-therapist	dentist	hygiene-therapist	dentist	hygiene-therapist	dentist	hygiene-therapist	dentist	hygiene-therapist
0 - 2	118,375	6,906	118,458	7,737	118,577	8,943	118,696	10,148	118,815	11,353	118,934	12,558	119,054	13,763	119,173	14,968	119,292	16,173	119,411	17,378
3-5	323,307	136,630	324,215	145,813	325,531	159,123	326,848	172,433	328,164	185,742	329,480	199,052	330,797	212,362	332,113	225,671	333,429	238,981	334,746	252,290
6-12	1,036,235	677,188	1,039,311	708,290	1,043,769	753,365	1,123,227	1,556,774	1,052,685	843,516	1,057,143	888,591	1,061,601	933,667	1,066,059	978,742	1,070,517	1,023,818	1,074,975	1,068,893
13 - 17	881,809	412,627	883,078	425,458	884,917	444,053	886,756	462,648	888,595	481,243	890,435	499,838	892,274	518,433	894,113	537,028	895,952	555,623	897,791	574,218
Total children's clinical time	2,359,726	1,233,351	2,365,062	1,287,298	2,372,794	1,365,484	2,455,527	2,202,003	2,388,259	1,521,854	2,395,992	1,600,039	2,403,726	1,678,225	2,411,458	1,756,409	2,419,190	1,834,595	2,426,923	1,912,779

Note: Red column represents age-specific clinical time in hours for hygiene-therapists while blue represents dentists' clinical hours

The overall changes in the clinical hours for both adults and children following 'more prevention' scenario are presented in **Table 8-20**.

**Table 8-20 DENTASSim scenario 4 'more prevention' overall clinical hours**

% of children's treatment plans with fluoride varnish	Overall clinical hours for dentists	% of overall clinical time for dentist	Overall clinical hours for hygiene-therapist	% of overall clinical time for hygiene-therapists
Base 13. 1% rate of fluoride varnish	13,610,437	70.5%	5,683,801	29.5%
20%	13,615,772	70.3%	5,737,749	29.7%
30%	13,623,505	69.9%	5,815,934	30.1%
40%	13,631,237	7.6%	5,894,119	30.5%
50%	13,638,970	70.7%	5,972,304	31.0%
60%	13,646,703	70.7%	6,050,490	31.4%
70%	13,654,435	70.8%	6,128,675	31.8%
80%	13,662,168	70.8%	6,206,860	32.2%
90%	13,669,900	70.8%	6,285,045	32.6%
100%	13,677,633	70.9%	6,363,230	33.0%

The findings indicate that increase in prevention, with the UPDA model, would increase the overall clinical time for dentists by only 0.4% while for hygiene-therapists this would be only 3%.

#### 8.4.5.2 DENTASSim scenario 4' more prevention' outputs - Whole Time Equivalents

**Table 8-21** below shows that the supply of hygiene-therapists would need to increase by 465 WTE if 100% of children's treatment plans included fluoride varnish compared with 45 WTE. This is based on 91% delegation (UPDA model).

**Table 8-21 DENTASSim scenario 4 'more prevention' overall change in WTE**

% of children's treatment plans with fluoride varnish	WTE for dentists	WTE for hygiene-therapists
Base 13. 1% rate of fluoride varnish	8,948	3,886
20%	8,952	3,923
30%	8,957	3,977
40%	8,962	4,030
50%	8,967	4,084
60%	8,972	4,137
70%	8,977	4,191
80%	8,982	4,244
90%	8,987	4,297
100%	8,993	4,351

#### 8.4.6 DENTASSim Scenario 5: 'Maximum skill mix'

Scenario 5 simulates an unlikely situation where all treatments that could possibly be undertaken by hygiene-therapists are undertaken by hygiene-therapists. The simulation involves apply 100% delegation of examinations, radiographs, tooth restorations, pulpotomies, fluoride varnishes, fissure sealants and scale/polish. Paediatric extractions were placed under dentists because there were less than 1% of clinical time and distinction of permanent or primary tooth extractions was not possible.

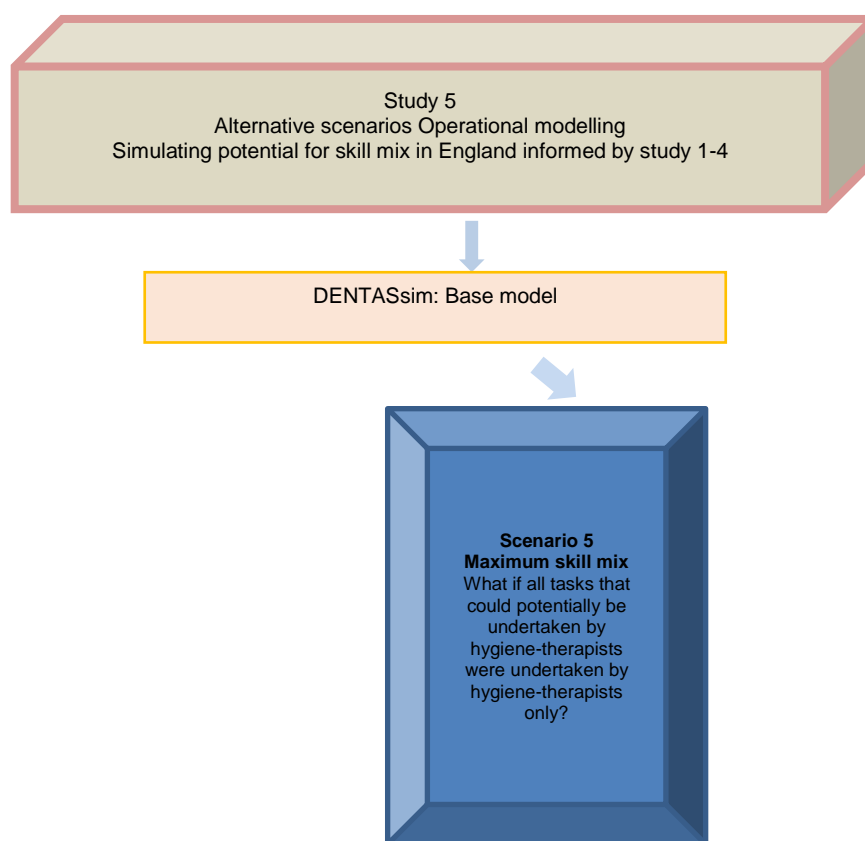


Figure 8-10 Scenario 5 'maximum skill mix'

**Table 8-22 DENTASSIM scenario 5 outputs ' maximum skill mix'**

Treatment	% of all clinical hours	Clinical hours	Dentist hours	Dentists % of all clinical hours	Hygiene-therapist hours	Hygiene-therapist % of all clinical hours
Examinations	29.40%	5,681,232	0	0.00%	5,681,232	29.40%
Tooth restoration	23.70%	4,567,989	2,283,995	11.90%	2,283,995	11.90%
Scale and Polish	17.20%	3,313,516	0	0.00%	3,313,516	17.20%
Tooth Extractions	5.80%	1,124,902	1,124,902	5.80%	0	0.00%
Radiographs	5.00%	959,216	479,608	2.50%	479,608	2.50%
Crowns	4.40%	843,477	843,477	4.40%	0	0.00%
Endodontic Treatment	4.10%	790,306	778,149	4.00%	12,156	0.10%
Upper Denture Acrylic	4.00%	769,660	769,660	4.00%	0	0.00%
Lower Denture Acrylic	2.40%	462,908	462,908	2.40%	0	0.00%
Bridge units	1.10%	201,919	201,919	1.00%	0	0.00%
Inlays	0.90%	167,545	167,545	0.90%	0	0.00%
Fluoride Varnish	0.70%	143,009	0	0.00%	143,009	0.70%
Fissure Sealants	0.50%	90,220	0	0.00%	90,220	0.50%
Upper Denture Metal	0.40%	72,887	72,887	0.40%	0	0.00%
Antibiotic Items Prescribed	0.20%	40,113	40,113	0.20%	0	0.00%
Lower Denture Metal	0.20%	37,377	37,377	0.20%	0	0.00%
Veneers Applied	0.10%	27,962	27,962	0.10%	0	0.00%
<b>Total</b>	<b>100%</b>	<b>19,294,238</b>	<b>4,526,899</b>	<b>37.80%</b>	<b>14,677,118</b>	<b>62.30%</b>

Note: Red column represents age-specific clinical time in hours for hygiene-therapists while blue represents dentists' clinical hours

Table 8-22 shows that the results of the clinical hours that would be assigned to hygiene-therapists and dentists following a maximum skill mix simulation. The total amount of time to hygiene-therapists would be 77% compared to 23% for dentists.

**Table 8-23 DENTASSim Scenario 5: 'maximum skill mix' clinical hours by age group**

Age groups	Clinical hours	% of total hours	dentist hours	dentist % of all clinical hours	hygiene-therapist hours	hygiene-therapist % of all clinical hours
<b>0 - 2yrs</b>	125,281.40	0.6%	2,971	0.0%	122,311	0.6%
<b>3 - 5yrs</b>	459,936.40	2.4%	81,272	0.4%	378,665	2.0%
<b>6 - 12yrs</b>	1,713,423	8.9%	449,314	2.3%	1,264,108	6.6%
<b>13 - 17yrs</b>	1,294,437	6.7%	383,703	2.0%	910,734	4.7%
<b>18 - 24yrs</b>	1,319,555	6.8%	456,484	2.4%	863,072	4.5%
<b>25 - 34yrs</b>	2,355,367	12.2%	898,823	4.7%	1,456,544	7.5%
<b>35 - 44yrs</b>	2,881,285	14.9%	1,109,669	5.8%	1,771,616	9.2%
<b>45 - 54yrs</b>	3,120,443	16.2%	1,294,710	6.7%	1,825,733	9.5%
<b>55 - 64yrs</b>	2,738,878	14.2%	1,163,699	6.0%	1,575,180	8.2%
<b>65 - 74yrs</b>	2,015,668	10.4%	865,034	4.5%	1,150,634	6.0%
<b>75+yrs</b>	1,269,964	6.6%	596,980	3.1%	672,984	3.5%
<b>total hours</b>	19,294,238	100.0%	7,302,658	37.8%	11,991,580	62.2%

Note: Red column represents age-specific clinical time in hours for hygiene-therapists while blue represents dentists' clinical hours

Table 8-23 indicates that with the maximum delegation model the majority of hygiene-therapists time would be spent on 35—44 year olds (9.2% of total clinical time) and 45-54 year olds. (9.5% of total clinical time)

#### **8.4.6.1 DENTASSim scenario 5 outputs 'maximum skill mix' Whole time equivalent**

The clinical hours shown were converted to whole time equivalents using DENTASSim'. The result is that 2,976 WTE dentists and 10,097 WTE hygiene-therapists would be required with a 'maximum skill mix' scenario based on the model.

## 8.5 Cost minimisation and workforce numbers

### 8.5.1 Cost minimisation

Cost minimisation was undertaken using salary costs in **Table 8-24** as obtained from the National Careers Service (National Careers Service, 2013). These were modelled to the WTE estimated by the scenarios and the results are shown in **Table 8-25**.

**Table 8-24 Salary costs from National Careers Service**

	Salary costs		
	Lower	Average	Upper
Dentist	£37,714	£59,194	£80,674
Hygiene-therapists	£21,200	£28,100	£35,000

Note: average was calculated based on the upper and lower ranges

Source: National Careers Service

(2013):<https://nationalcareersservice.direct.gov.uk/advice/planning/jobprof>

### 8.5.2 Applying workforce report data for England in NHS year 2011/12 to model findings

The report of dental statistics from the NHS information centre for the year 2011/12 indicates that 22,920 dentists performed all the treatment activity in the year 2011/12. From the survey *'Modelling the dental workforce supply in England'* (Robinson et al., 2011) dentists reported working 62% of time in the NHS of which 83.5% is clinical time. Therefore this suggests that dentists worked 0.5WTE on clinical work in the NHS. If an additional 4 weeks of time is taken for annual leave, as suggested in the dental working hours survey 2011/12, this will mean that the 22,920 dentists were working 0.4WTE on NHS clinical work only. This was calculated as followed

$$1) \quad 62\% \text{ of time} \times 0.85 \times 0.93 = 0.4\text{WTE}$$

This 0.4WTE is used to calculate the estimated NHS personnel based on model outputs.

With the national data, it is not possible to ascertain the number of DCPs involved in care. It is, however, possible to estimate the number of hygiene-therapists or equally skilled personnel who would be required in the NHS the WTE for hygiene-therapists as estimated by Robinson et al survey (Robinson et al., 2011) to the estimated total WTE simulated by DENTASSim scenarios. According to the survey, hygiene-therapist's work 54% in NHS and 90% is on clinical tasks.



$$1) \quad 0.5 \text{ WTE (on NHS) } \times 90\% \text{ (clinical time) } \times 75\% \text{ (non-annual leave)} = 0.3 \text{ WTE}$$

.

There are 2,128 hygiene-therapists registered to addresses in England and 5,152 hygienists are registered to an address in England. The therapists who are dually trained would be registered also as hygienists, making the number of hygienist-only practitioners less than 5,152. **Table 8-25** presents all scenarios compared for the estimated number of NHS personnel that would be required based on survey data and salary costs calculated from National careers services figures. It also shows the potential salary savings between scenarios in reference to 'no skill mix'.

**Table 8-25 All scenarios cost minimisation and workforce numbers outputs**

	Dental professional	DENTASSim Clinical time in hours	DENTASSim WTE	Estimated NHS Number of personnel required to meet total demand	Ratio of NHS personnel Dentist to hygiene-therapist	Minimum salary cost	Average salary cost	Maximum salary cost	% salary cost saving between no skill mix and other scenarios
<b>DENTASSim (base model)</b>		19,294,238							
<b>Scenario 1: 'No skill mix' (dentists only)</b>	<i>Dentists only</i>	19,294,238	12,685	24,736		<b>£478,410,847</b>	<b>£750,889,634</b>	<b>£1,023,368,422</b>	0%
<b>Scenario 2: 'UPDA National'</b>	<i>Dentists</i>	13,610,437	8,948	17,449	1.8:1	£337,477,981	£529,688,487	£721,898,993	
	<i>Hygiene-therapists</i>	5,683,801	3,886	9,716		£82,390,832	£109,206,716	£136,022,600	
<b>Total</b>				<b>27,165</b>		<b>£419,868,813</b>	<b>£638,895,203</b>	<b>£857,921,593</b>	19%
<b>Scenario 3: 'Direct access' 70% exams delegated +UPDA</b>	<i>Dentist</i>	9,633,574	6,334	12,351	1:1.3	£238,869,572	£374,917,681	£510,965,790	
	<i>Hygiene-therapists</i>	9,660,664	6,606	16,513		£140,038,342	£185,616,859	£231,195,376	
				<b>28,864</b>		<b>£378,907,914</b>	<b>£560,534,540</b>	<b>£742,161,167</b>	38%
<b>Scenario 4: 'More prevention' 50% of children receive fluoride varnish +UPDA</b>	<i>Dentists</i>	13,623,505	8,967	17,466	1.8:1	£338,185,478	£530,798,939	£723,412,400	
	<i>Hygiene-therapists</i>	5,815,934	4,084	9,941		£86,572,892	£114,749,918	£142,926,945	18%
<b>Total</b>				<b>27,407</b>		<b>£424,758,370</b>	<b>£645,548,858</b>	<b>£866,339,345</b>	
<b>Scenario 5: 'Maximum delegation'</b>	<i>Dentists</i>	7,290,502	4,801	9,346	1:2	£181,073,278	£284,203,521	£387,333,764	
	<i>Hygiene-therapists</i>	11,913,515	8,199	20,365		£173,826,662	£230,402,321	£286,977,980	52%
<b>Total</b>				<b>29,711</b>		<b>£354,899,939</b>	<b>£514,605,842</b>	<b>£674,311,744</b>	

Salary source: National Careers Service <https://nationalcareersservice.direct.gov.uk/Pages/Home.aspx> (2013)

Note: Number of personnel is calculated based on working hours described by Robinson et al (2011) i.e WTE for clinical time only within the NHS::dentists 0.4 WTE and 0.3 for hygiene-therapists. Salary is calculated based on WTE derived from DENTASSim WTE in column three of the table

### **8.5.3 Summary**

This chapter demonstrates the potential for skill mix in primary dental care through a range of alternative scenarios. The model components consist of age-specific, treatment-specific, delegation rates (from dentists to hygiene-therapist) and clinical time required to perform treatments. The outputs of the model are clinical hours and WTE.

#### **8.5.3.1 Base model**

The base model provides account of clinical time. It suggests that among individual treatment groups, examinations account for the most time (29.4% of total clinical time), and followed by tooth restorations (23.7% of total clinical time). Further grouping of treatments based on jurisdictions as identified by the scope of practice (General Dental Council, 2013), suggest that the treatments within contested jurisdiction i.e hygiene-therapists and dentists can both perform these treatments, represent 77% of all clinical time. However, it is noted that for Paediatric endodontic treatment and extractions, it is not possible to ascertain whether these were on primary teeth. Radiographs and tooth restorations are the same, as radiographs could have been part of endodontic treatment and tooth restorations may have been technically complicated. Therefore, 77% is an overestimate.

In considering age, the group of patients aged 45-54 year olds would account for the most demand for care according to the model. Most of the time spent on their care is examinations followed by tooth restorations.

#### **8.5.3.2 Scenario 1: 'No skill mix'**

The 'no skill mix scenario' proportions all care to dentists. This scenario, transfers all the base model clinical time to the dentist, as all treatments are within their scope. According to the model this would amount to a need for 12,685 WTE, working to undertake 19,294,238 of clinical. Estimated number of NHS dentists would be 24,736. This is 7% more than the 22,920 who were listed to have undertaken NHS care in 2011/12. This suggests a level of DCP care was possibly used in that year. The total average cost would be £750,889,634, which is affordable based on the knowledge that NHS primary dental care costs about £3.4bn.

### **Scenario 2: 'UPDA National'**

The model output indicated that 29.5% of all clinical hours could be performed by hygiene-therapists if UPDAs model would have been adopted nationally in 2011/12. The model suggests that an estimated 57% of the currently available registered dentists in England would need to be involved in NHS care but

#### **8.5.3.3 Scenario 3: 'Direct access'**

Different rates of direct access led to data indicating that at a ratio of 1:1 of dentists to hygiene-therapist would occur with about 70% of examinations being done by hygiene-therapists and within the delegation rate practiced at UPDA. If only 10% of assessments were conducted by hygiene-therapists, 3% of all clinical time would be shifted from dentist to hygiene-therapists. Considering that 4.1% of all clinical hours were taken up endodontics, 3% is a useful clinical time saving.

#### **8.5.3.4 Scenario 4: 'More prevention'**

If the rate of fluoride varnish were to increase from 13.1% to 100% in children's treatment plants. These would lead to 465 increases in WTE of hygiene-therapists or other DCP who can perform fluoride varnish compared to 45 WTE dentists. This is based on a 91% fluoride varnish delegation rate to hygiene-therapists.

#### **8.5.3.5 Scenario 5 'Maximum skill mix'**

The maximum skill mix model allocates all examinations to hygiene-therapists, 50% radiographs, 50% restorations and all prevention also to hygiene-therapists. The results are that only 4,801WTE dentists and 8,199 hygiene-therapists would be required to meet the total demand for care.

#### **8.5.3.6 Overall scenario comparisons and cost minimisation**

In comparing scenarios two to five to scenario one, which is no skill mix. The model suggests that there would be salary costs saved through the use of skill mix. First, with the UPDA model a 19% salary cost would be achieved and direct access at the rate of 70% within the UPDA model would lead to 38% salary cost saving.

In comparing the findings of the DENTASSim to the current workforce available in England, the results reveal that there is room for the training of more dually qualified hygiene-therapists or apportioning of care to other DCPs with the same skill. Furthermore, it is clear that more information on the DCPs who are involved in care is needed on a national level. With the workforce available now, dentists appear to have more time for complex procedures if they utilised the skills available among DCPs. The comparability of the numbers is as good as the data available. The model has flexibility allowing average work and annual leave and skill proportioning to be varied and can be applied to different treatment demand, delegation rates and payments.

## Chapter 9 Discussion

### 9.1 Introduction

This research advances the knowledge concerning the nature of care needs presenting in primary dental care and highlights the relationship between patient socio-demography and expressed treatment needs (care provided based on normative assessment and patient's desire). It has further quantified the potential contributions from mid-level dental providers to meeting these expressed needs in primary dental care.

#### 9.1.1 Summary of the key findings

- First, the patient base represented all sections of society; however, in the transition from a service training only DCPs to one that expanded to include dental students, service uptake changed by age group and social deprivation. There was an increase in the proportion of older patients and those who would have normally had to pay for services. The ratio between child and adult patients remained 1:4 before and after the service changed. Whilst there was greater use from the less deprived, those who were 'geographically deprived from services' were more likely to access the new service.
- Second, within the limitations of the dataset, there were distinct patterns of treatment across the socio-demographic spectrum (age, sex, exemption status, social deprivation) and smoking. With every year of increasing age, adults were more likely to receive one or more of the following: partial dentures (7%); tooth extraction (3%); instruction advice (3%); scale and polish (3%).
  - a. Patients identified as smokers were more likely to require one or more of the full spectrum of treatments compared with non-smokers including: instruction/advice (x4); partial dentures (x3); extraction (x2); scale and polish (x1.7); tooth restorations (x1.5).
  - b. Patients who were exempt from payment were more likely to require one or more of the following: partial dentures (x2.6); tooth restorations (x2); instruction/advice (x2); tooth extraction (x1.8); scale and polish (x1.7).

- c. Deprivation status, based on IMD scores using local quintiles: when compared with the least deprived quintile, the most deprived were more likely to have received the following at least once in the four-year period: tooth restorations (x1.7); tooth extraction (x1.5); however, they were less likely to have received instruction/advice (x0.3); scale and polish (x0.5).
  - d. Females were less likely to receive tooth restorations and tooth extractions than males.
- Third, overall, in relation to delegation to hygiene-therapy students, 52% of the sample of patients who had received treatments coded for delegation (tooth restorations, fissure sealants, pulpotomy and paediatric tooth extractions) were delegated to HTS; while 46% of the treatment items were delegated. A higher proportion of children and adult smokers were delegated to hygiene-therapy students than adults and non-smokers. Tooth restorations were delegated at a significantly higher rate for children and smokers, whilst fissure sealants were delegated at a significantly higher rate for females.
- Fourth, modelling of national scenarios suggests that the proportion of clinical time solely within the dentists' jurisdiction is 23% of total clinical time, while 77% lies within the scope of both dentists and dental hygiene-therapists. The scenarios simulation suggest that:
  - a. A 'no skill mix' model of practice where dentists perform all care would lead to the need for 12,685 WTE based on the DENTASSim model. If estimated NHS clinical working hours were applied, this would require 24,736 dentists. This is 18% less than the current 30,447 dentists registered with addresses in England. Meaning 81% of dentists would be required to be involved in NHS care. The salary cost of this scenario is based on WTE and is estimated at an average of £750,889,634
  - b. UPDA model of skill mix practice would lead to 29.5% of all clinical time undertaken by hygiene-therapists. The WTE ratio of dentist to hygiene-

therapists would be 2:1. If NHS estimated clinical working patterns are applied, this would translate to a need for 17,449 dentists which is 57% of dentist registered in England, whilst at least a 357% increase in the number of hygiene-therapists registered in England would be required. This model would lead to a 19% salary cost saving from a 'no skill mix' model.

- c. A minimal direct access model (70% examinations delegated to hygiene-therapists), while maintaining UPDA model of skill mix, would lead to a 1:1.3 dentist to hygiene-therapist WTE ratio. Estimated NHS clinical working patterns would lead to a need for 40% of dentists registered undertaking NHS care with eight times the number of hygiene-therapists registered in England and this would translate to a 38% cost saving from 'no skill mix'
- d. Increase in evidence-based practice (fluoride varnish from 13% to 50%), with UPDA model of skill mix practice, would lead to a 2:1 dentists to hygiene therapist WTE ratio. Estimated NHS clinical working patterns would lead to a need for 29.3% less number. of dentists compared with a 'no skill mix' model and 4.7 times the number of hygiene-therapists registered in England. This would lead to an 18% decrease in salary cost compared with a 'no skill mix' model where only 13% of prevention (fluoride varnish) is undertaken and 0% is delegated to hygiene-therapist.
- e. A maximum skill mix situation where all prevention and 50% of contested care (tooth restorations and radiographs) were delegated would lead to 1:2 dentists to hygiene therapist WTE ratio. NHS clinical working patterns would translate to 30% of registered dentists being involved in care and ten times the number of hygiene-therapists currently registered in England. A 52% salary cost saving could be achieved compared to a dentists only model.

### **9.1.2 Introduction to discussion**

In the following sections, the research findings will be discussed sequentially under central themes related to the objectives outlined in Section 3.2. First, the findings related to the demography of the patient base are discussed in relation to primary care populations in England and dental access barriers. Second, the results that presented a view of predictors of expressed



treatment needs are discussed. Third, the findings related to the use of skill mix use in UPDA and their similarities to other studies of skill mix are addressed. Fourth, is a look at operational research findings and the implications of these findings to the dental workforce in England, jurisdictional claim for DCPs and the organisation of primary dental care. Fifth, the strengths and limitations of this work are outlined.

## **9.2 Patient base in primary care services**

### **9.2.1 Introduction**

In addressing the first objective the findings revealed that the patient base represented a wide spectrum of age, sex and social class (as described by deprivation quintiles) in society. Primarily, this indicated that there were equal opportunities for access into the primary care services, as well as a range of opportunities for students to treat the societal spectrum. This is significant in relation to ascertaining the transferability of patterns of practice developed in outreach setting into regular primary care settings. These findings are similar to findings from Elkind et al. (2005), who found that a suitable patient base can be established in an outreach setting offering students the opportunity to provide comprehensive care in a primary care setting.

There were, however, evident variations in the rate of uptake of the new service by socio-demography, especially in the initial phase of UPDA's establishment. These variations relate to 'access behaviour' and corroborate findings from studies that have investigated and confirmed that individual and contextual factors influence dental service utilisation (Atchison and Andersen, 2000, Scheutz and Heidmann, 2001, Dobalian et al., 2003, Baker, 2009, Marshman et al., 2012). This research has shown that the new patient base was older, less deprived and non-exempt from NHS payment. In the next sections the patterns in access in relation to the new services are discussed in detail.

### **9.2.2 Patient age and access to the new service**

The patient base, following the establishment of UPDA, was on average older. In analysing the proportion of patients within each of the eleven NHS age groups the data revealed that whilst the number of patients over the age of 75 years was low, their volume almost tripled after UPDA opened. Similarly, 55-64 year olds and 65- 74 year olds doubled. The increase in middle-aged patients (55-64 years) could have been related to treatment demand as the ADHS did show that patients between 44-54 years and 55-64 years were increasingly undergoing routine care. By contrast, in older adult patients, dental access rates were low locally and nationwide (Steele and O'Sullivan, 2011, NHS Dental Public Health Team, 2011). Possible explanations for these increases could be an increase in treatment need of all groups including older age groups, as

evidence has already been indicated, and the fact that people are retaining teeth longer, leading to a need for more complex care (Steele and O'Sullivan, 2011). An alternative explanation could be that the removal of known barriers to dental service access as discussed below, may have promoted the service to these groups of patients.

#### **9.2.2.1 Cost as a barrier to dental services**

The services offered at UPDA are free at the point of delivery, whereas before UPDA patients had to pay for care. The cost-free service may have appealed to older patients in particular, as literature does suggest that cost is commonly cited as a barrier to dental service access for older patients in England, (Wylie and British Dental Association, 2003, Borreani et al., 2008). In comparison to other areas of health, access to dental services by older adults is particularly viewed to be hampered due to cost. In a longitudinal study of use of preventative primary care services by older adult women in England undertaken by Patel et al. (2007), it was suggested that older women of lower socio-economic status were less likely to have recent flu vaccinations, dental, eye and chiropody examinations, and the authors particularly highlight that cost may not explain inequalities in use of dental examinations (Patel et al., 2007). Lang et al (2008) also found that older people who lived in deprived areas of England were at particularly greater risk of poor access to dental services and that targeting older people in poor neighbourhoods should be a priority.

#### **9.2.2.2 Increase in treatment need and access to dental services**

The second likely explanation for the increase in an older patient base relates to the nature of treatment need and increased capacity. With the additional presence of dental students in training, more opportunities existed for additional prosthodontic care (dentures and crowns), which is a prevalent treatment need among older patients (Kelly et al., 2000, Pearson et al., 2007, Borreani et al., 2009, Yamamoto et al., 2014). Community outreach is traditionally considered an ideal opportunity for dental students to improve their clinical expertise especially with such complex care (Elkind A, 2002, Smith et al., 2006c). The ADHS did highlight that patients over the age of 45 were more likely to receive crowns. It may have been the case that dental students were readily available to provide these types of services and patients who needed prosthodontic care were now aware of the new capacity for the provision of this service. This also falls in line with the theory of increased awareness among the older adult populations

of today, as they have been found to be better informed and more demanding of oral healthcare providers than previous generations (Allen et al., 2011). In further support of this, the data revealed an increase in the numbers of laboratory constructed devices (prosthodontic treatments) in the period post expansion, compared with the period before and this was predicted by older age (Wanyonyi et al., 2013). A study by Zammit et al. (1993) found similar results, where dentures doubled in number after services were free. In addition to national survey findings that indicate an increase in complex care needs in adult demographic groups (Steele and O'Sullivan, 2011) , it may be plausible to suggest that the nature of care provided at UPDA could have suited the needs of middle-aged and older patients. This has implications for clinical time saving and there being room for DCPs to undertake routine care to free up time for complex care practice.

#### **9.2.2.3 Timing and access to dental services**

The third explanation is that time may have been a factor in the improved access of the older patients to the service. Appointment times in a student-led service were viewed as more favourable to older patients who may have retired. This is suggested because student clinics are likely to be ongoing in the mid-morning or mid-afternoon, which may be more difficult to attend if in full-time employment but favourable to pensioners. In addition, older patients in England, are allowed to travel free during off-peak times - mornings and afternoons (Age UK, 2014) - thus the student clinic times would be suitable. Researchers have also recommended that clinicians consider appointment times more carefully when booking older patients in England, due to factors such as free travel (Borreani et al., 2008, Borreani et al., 2009, Borreani et al., 2010).

In brief, the evidence of an increase in older patients who may have found the new free service with increased capacity more attractive than other age groups emphasises the unmet needs of this group of the population. It is proposed that the new service, now fully equipped with a dental team working together, may be attracting a profile of patients reflective of the range of skills available, which is representative of primary care. It is recommended that more centred care is considered for older patients and there is a challenge to think beyond the normal general practice routine for those who may not be able to even attend a free service (Bethel et al.,

2014). For older adults eliminating the known barriers to dental service may improve dental access and lead to their better oral health (Wylie and British Dental Association, 2003).

### **9.2.3 Deprivation and access to dental services**

The new service was shown to have initially attracted patients with a lower overall deprivation score and higher geographical barriers to services scores, when compared to the period before. The mean deprivation score reduced from 24.5 (S.D 14.5) to 22.3 (SD13.8) in the first year of the new service with team training. It seemed to change back to the same profile as the period before UPDA in the second year of team training. This is indicated by the proportion of completed/closed treatment plans from patients from the least deprived quintile dropping from 18.4% in the first year of team training to 16.4% in the second year of team training; closely similar to the proportion before team training which was 16.1%.

Despite the geographical location of UPDA adjacent to some of the most deprived areas in Portsmouth, the majority attended from further away. The GIS mapping of patients' residences further validated these differences visually, by indicating that the initial phase of the new services attracted patients from a wider radius, compared with the period before UPDA. Statistical analysis of geographical deprivation by GBS scores indicated that the patients in the first year of team training came from areas more geographically deprived from services compared with the period before UPDA. Similar findings were seen in a study by Lang et al. (2008) of individuals aged 65+ in the 2005 Health Survey for England which showed that deprivation was associated with less regular dental access, while urbanisation was not associated with services access. In contrast, in studies of Dental Access Centres (DAC), which were established for high needs unregistered patients in areas with fewer dental services, the majority of patients were found to be from the local post-codes (Harris and Burnside, 2007, Milsom et al., 2009). The findings from UPDA contradict popular recommendations, that suggest that locating primary dental care services adjacent to lower socio-economic groups improves access (Tickle et al., 2000, Maunder et al., 2006, Morris and Landes, 2006, Landes and Holmes, 2012). The findings may substantiate the arguments from Currie et al (2012), who proposed that publicly funded care should avoid polarising dental services further by locating services in 'areas of poverty and high needs'.

Despite the fact that the data suggested that physical location of UPDA did not necessarily make the service more accessible to individuals from the surrounding areas, wider factors associated with service access were reviewed for a possible explanation of these findings. One consideration may be that those from less deprived quintiles may represent 'worried-well' who popularly are the first to uptake services and are usually not deprived (Currie et al., 2012). An additional explanation considered for the patterns described is associated with the patient access pathway in UPDA, which changed. While the patients who visited before UPDA would walk in, in the UPDA period there was a reliance on a county-wide dental helpline and internet booking system (Solent NHS Trust, 2011). The ability of helplines to improve access has not yet been sufficiently substantiated (Harris, 2003). It has even been suggested that dental helplines could lead to widening of the inequalities gap (Ellins and McIver, 2008). Ellins and McIver (2008) suggested that for hard-to-reach groups such as deprived communities, a consultative approach with the communities is one of the best ways to inform them of services. In addition, there is a need to consider the literacy and comprehension of health information, which can be a barrier for some potential patients (Ellins and McIver, 2008). These inverse access patterns even in the presence of services, continue to emphasise the complexity in improving dental access for disadvantaged groups.

This is not to propose that helplines and the internet lack a role in improving access to health services, but it is perhaps worthwhile to ascertain whether the protocols used by helpline staff increase the uptake of hard to reach groups. The use of the internet is particularly an area for more research, especially with the rise of internet use. Reports in 2013 indicated that 36 million adults (73%) in Great Britain accessed the internet every day; 20 million more than in 2006, when directly comparable records began (Office of National Statistics, 2013). A study almost 10 years ago found that even in a group of university students the internet was not quite the first point of information when it came to dental issues (Harris and Chestnutt, 2005). However, much has changed since then, with mobile internet-enabled devices becoming widespread. It is consistently important to appreciate the complexities of improving access in deprived groups especially as we move to new media and more sophisticated devices in order to engage the public with health services. To quote Pavi et al. (1995) 'the barriers to access in deprived groups are not easily modifiable but belong to a group of issues which relate to a social political

agenda' (Pavi et al., 1995). There is a need for a concerted effort to understand the needs of disadvantaged groups and UPDA has made efforts to undertake mobile outreach into the community to better introduce the services and provide health promotion.

In summary, these findings relating to access to the new primary dental services corroborate the literature around the variation in dental access behaviour among different groups. The specific age group and deprivation differences in dental access, and the explanations proposed in this study, offer information on what factors should be considered when planning for the use of new services. In the context of England, the new dental contracts begin to take a step towards recognising the diversity in patient access behaviour through weighted capitation (Department of Health, 2010b). This can be argued as a purposeful direction into improving 'entry access' and 'effective access' (Harris 2012). If the primary goal is to encourage a first point of entry into the dental service system, the information from this analysis legitimises recommendations for more tailored support around improving access for patients such as older adults (Petersen and Yamamoto, 2005, Pearson et al., 2007, Lang et al., 2008, Borreani et al., 2009, Borreani et al., 2010, Purandare et al., 2010).

## **9.3 Patterns of expressed treatment need**

### **9.3.1 Introduction**

This service presented a good setting to examine treatment need/expressed need as the findings were comparable to national survey findings, while providing greater detail (See Appendix 10.6.22). The findings did address the second objective of this research which sought to investigate the relationship between treatment and socio-demography of patients. This resulted in a detailed description of treatment demand in a primary care setting, showing who and which types of treatments commonly presented in this setting. These are relevant findings for the appropriate planning for the workforce or services. The findings suggest that factors such as age, gender, adult payment status, deprivation and smoking have an influence on treatment and contribute some answers to the questions asked by researchers about what kind of services are required (Brocklehurst and Tickle, 2011b). Another reason as to why the findings from this study were considered to be useful for the wider primary was the practice protocols in place at UPDA and the predecessor organisation, which ensured that patients were engaged in the process of treatment planning. Again, these were found to be particularly valid, due to the elimination of biases related to response and recall highlighted in surveys and studies that use self-reported information (Steele and O'Sullivan, 2011, Marshman et al., 2012, Csikar et al., 2013).

Further still the results corroborated the existent evidence of relationship between an ageing population and increased dental needs (Akar and Ergul, 2008, Allen et al., 2011, Castronuovo et al., 2007, Frenkel et al., 2001, Gluhak et al., 2010, Jager et al., 2009, Purandare et al., 2010, Unluer et al., 2007, Zammit, 1993, Gallagher et al., 2010); studies have also shown differing response to prevention by sex (Green and Pope, 1999, Zakrzewska, 1996). The findings also related to previous data that has suggested that deprivation and area of residence have an influence on oral health (Siegel et al., 2014, Jamieson et al., 2013, Mejia et al., 2010, Parker et al., 2010). In addition, the evidence of smoking as a predictor of treatment needs is relevant to current policy, as smoking cessation has been a target for government programmes due to the understanding of its role as a common risk to several chronic illness (Department of Health, 2008c, Department of Health, 2007b). In the following sections each of the predictors of treatment need are discussed.



### 9.3.2 Age and treatment

In this study, increasing age was related to increased volume of treatment in general and more complex treatments (laboratory constructed devices and time consuming treatments). Multivariate analysis showed that for every year of age adults were 7% more likely to have a partial denture while adjusting for all other variables. This finding compares with evidence from England and Europe that there are higher needs among older patients especially for denture treatments (Unluer et al., 2007, Warpeha, 2011, Allen et al., 2011, Steele and O'Sullivan, 2011). From the UPDA data, the first two years of team training showed evidence of an increase in completed treatment plans undertaken on patients who were middle-aged (45-64years) and older (over 65 years). In addition crowns were more likely in middle-aged and older patients and this is similar to survey findings that have shown older adults had much higher numbers of bridges and dentures (White et al., 2012) and the ADHS 2009 which shows that adults over the age of 45 were more likely to receive crowns.

Age related differences in treatment require close consideration especially with the growing and ageing population in many western countries (Atchison and Andersen, 2000, Centre for Workforce Intelligence, 2014a). The literature has shown that health policy is geared to ensuring the right services are provided for older adults (Department of Health, 2014b); however this is not optimal and many older adults find themselves in care homes where their needs for dentures and crowns are not met (Akar and Ergul, 2008, Purandare et al., 2010). Studies have also shown that when older patients have more complex general health problems their edentulous state is often ignored (Gluhak et al., 2010). This is particularly a concern because more medically compromised adults or older people have been found to be the most likely to need dentures and bridges in other developed countries (Yamamoto et al., 2014). This research suggests that there is a need for these treatments as more aged patients present and therefore such workforce skills will need to be made available.

The higher expressed treatment need with increasing age requires a wider system approach in order to cope with the demand for their care, which is likely to increase (Gallagher et al., 2010, Watt et al., 2013). Developing countries have found benefit in the use of dental care professionals in providing dentures for patients, with a study from Cameroon suggesting that 98% of all dentures were undertaken by mid-level providers (Achembong et al., 2012). In

developed countries, such as Scotland, the potential for mid-level dental providers, in particular clinical dental technicians, to make an impact on the provision of specific areas of oral care has been proposed (Ross and Ibbetson, 2005, Ross et al., 2007b). In England, Gallagher et al. (2010) showed evidence of the potential that clinical dental technicians can have in meeting the expected future increase in demand for dentures among the older adults. In the past, the feeling from clinical dental technicians has been that they have been undervalued and at the time they looked forward to formal registration with the GDC to improve their position within the dental team (Bower et al., 2004). At present, research suggests that they are still largely working part-time, and even within this time, only about 50% is spent on NHS services (Robinson et al., 2011).

The evidence from this study supports the common understanding that complex (laboratory constructed device) care is increasing and is related to the older demographic. It appears that this is a time to ensure the right personnel are in place in order to meet this future demand. At present as primary dental care is changing and a new contract is about to take shape, weighting is being considered; it may be beneficial to target older patients as a likely recipient of higher weighting.

### **9.3.3 Patient sex and treatment**

Significant differences in expressed treatment needs between the sexes emerged in this research, with females 20% less likely to have tooth extractions, and 20% less likely to have tooth restorations than males, when other variables such as smoking, deprivation, payment exemption and age are controlled for. These differences are expected as there is an accepted premise that there are differences in the patterns of dental disease as women access dental care differently and react to health promotion in a more positive manner (Zakrzewska, 1996, Green and Pope, 1999, Murakami et al., 2014).

Considering the difference in tooth extraction, this could be due to the different attitudes towards treatment between the sexes. Studies have shown that men in England are less likely to opt for restoration and less likely to visit the dentist than women (Steele et al., 1996). It was, however, interesting to find that also with tooth restorations, women were less likely to have undergone this treatment than males. The stratified model indicated that male patients who were payment

exempt were four times more likely to have tooth restorations than non-exempt males, while females who were payment exempt were 1.4 times more likely to have tooth restorations than non-exempt counterparts. This does bring to light the possibility of looking at the cost of dental treatment and its impact between the sexes.

There is increasing research on the differences in sex and utilisation of dental services for dental diseases, with studies highlighting the predisposition for women to have periodontal problems due to hormonal differences (Jeffcoat et al., 2014). Dental anxiety has also been highlighted for its role in dental service utilisation and studies have shown that women have significantly higher dental anxiety scores than men in England (Humphris et al., 2013). It may be interesting to ascertain whether women and males are more anxious about different treatments. The other aspect of dental treatment that has previously shown gender differences is prevention seeking, and this relates to health seeking behaviour in general (Murakami et al 2014). Although the findings in this study do not show a higher propensity for preventative care for women it does bring to mind the idea that eliminating cost may attenuate the differences in the type of treatment patients decide to undertake, particularly between the genders.

As dental services strive to provide more preventive and quality care, there may be a benefit in looking at wider health research concepts around improving health seeking behaviour between different groups. An example is the concept of social capital which is considered to be important to improving appropriate health seeking behaviour (Mackian et al., 2004) and which has been shown to improve denture seeking in females (Yamamoto et al., 2014).

#### **9.3.4 Contextual influences, deprivation and treatment**

The results also highlighted that there were area level influences on treatments. This was initially indicated by the statistically significant differences in the relationship between quintiles of deprivation in the PCT, and the number of patients who had received extractions, scale polish and instruction/advice. It was revealed that those who were from the most deprived groups were 1.5 times more likely to receive tooth extractions and 0.5 times less likely to receive a scale and polish than those who are from the least deprived quintiles. These findings do however need to be considered with caution as there are limitations in using area level measures of deprivation

to predict individual level factors; this limitation was highlighted by Marshaman et al. (2012) as they investigated oral health needs in the UK.

However, using area level measures can help ascertain whether there are factors in a person's environment impacting on their health. Using multilevel analysis in this research uncovered a link between LSOA of residence and patient treatment. The results suggest that 7% of the variance in instruction/advice, 2.8% in tooth extraction and 3.6% in scale/polish can be explained by the LSOA of residence. When health deprivation score, an area level measure, was included with other individual level variables, the co-efficient were similar to a single level model. The findings do show that there is a small, but significant influence of a patient's place of residence and expressed treatment need. This is in line with the growing area of research into a link between deprived environment and oral health (Jamieson et al., 2013). A large body of work exists around the topic of where a person lives and their health within obesity research, and studies have suggested that neighbourhood characteristics such as presence of convenience stores, as opposed to supermarkets, have an influence on higher obesity rates in children (Turrell et al., 2004, Whitaker et al., 2013). Other public health concerns such as mental health have also been associated with neighbourhood characteristics (Stringer et al., 2006) and even more so household level influences (Weich et al., 2003). It is reasonable to suggest that in this study the areas with above average dental extraction rates should be subject to further analysis of factors such as convenience stores per square radius.

Adult payment status also had a significant influence on whether a patient had received extractions, scale polish, instruction/advice, tooth restorations, partial dentures and tooth extractions. This variable may be considered in the same category as deprivation scores, as it was highlighted in the first publication from this research that payment status acted as a proxy to overall deprivation score (Wanyonyi et al., 2013). It may be a stronger measure of individual deprivation than quintiles of deprivation or IMD measured at the area level. However, it is worth noting that some of the parameters that lead to exemption are dynamic e.g. pregnancy (NHS Choices, 2014).

The findings indicated that those adults who were exempt from payment were 1.8 times more likely to have extractions and less likely to have a scale and polish. They were, however, two

times more likely to receive instruction/advice than non-exempt adults and this reveals that those patients with apparent high need were receiving health promotion in UPDA. This is a different result from other studies in Europe, North America and Asia which have researched prevention and curative services in dentistry; where they have highlighted that preventative care is lower in lower income groups (Murakami et al., 2014, Grignon et al., 2010, Listl, 2011). The explanation for the high prevention uptake among the payment exempt adults may lie in the free services provided at UPDA. This further supports the market theory of oral health inequalities (Sisson, 2007), where the inability to afford services may lead to those who are lower in economic status and in higher need lacking care. In addition to the free service at UPDA, the strong focus on risk assessment and prevention could have played a role so more research to understand this association would be beneficial.

### **9.3.5 Smoking and treatment need**

Another finding was in regard to smoking. The average proportion of smokers was about 20%; this compares to Portsmouth city average of about 24% (Hampshire County Council, 2014). In the results, smoking was associated with advanced treatment needs such as tooth extractions, which is associated with late presentation or advanced disease (McCaul et al., 2001) and are therefore an undesirable treatment sequelae. These results are similar to findings from other studies which showed that smokers had a significantly higher mean tooth loss than non-tobacco users (Anand et al., 2012) and supports evidence which suggests that smokers have poorer self-rated oral health than non-smokers and are more likely to attend for emergency care (Csikar et al., 2013). It was, however, found that in this setting, smokers were four times more likely to receive instruction advice than non-smokers, which may be a result of the preventative focus of the university and use of smoking as a measure of risk for dental disease. This promotes the idea that protocols that encourage prevention and risk assessment could improve preventative practice.

Reports from the ADHS 2009 also show that smokers had a higher proportion of restorative and prosthodontic treatments than non-smokers (Steele and O'Sullivan, 2011). The significance of such findings is that they can be used to group patients into risk groups to try to ensure targeted care for smokers. The findings give a sense of a lengthy interaction with dental services for smokers and possibly even more invasive procedures such as implants later on (Ortega-

Martinez et al., 2012). Planners have an opportunity to perhaps provide some targeted messages to smokers who attend the dentist a number of times, warning them of the likelihood of future advanced treatment needs, which may be more costly and time consuming. The implication of this for human resources is the need for more capacity and health promotion, and notably, this is within the jurisdiction of DCPs.

#### **9.3.6 The potential contributions for the learning around needs and demand in primary dental care**

The relationships between the nature of treatment needed and demand associated with patient social characteristics warrant further exploration. These findings advance the literature regarding the importance of a wider understanding of patient's circumstances in the planning of care. The evidence indicated that the area of residence may have additional factors which may influence health needs as demonstrated by significant variation in the nature of demand in different geographical areas. Although certain treatments such as tooth extractions provided an indication of severity of diseases, close consideration of developing diagnostic codes for primary care dentistry within patient management systems would be very worthwhile. This would be able to definitively ascertain the level of need and the reasonable care that should be provided.

## **9.4 Skill mix**

### **9.4.1 Introduction**

The third objective for this research was to examine skill mix in practice. There is a limited amount of data on the productivity of dental therapists in general practice roles. The findings from the analysis of patient management data made it possible to uncover a pattern of skill mix between DS and HTS, through analysis of delegation of patients and tasks.

A data set derived from the main extract, using high level procedures which had treatments coded by the provider was used for the skill mix analysis and from these data, 55% of patients had been delegated at least once for treatment by HTS. This is likely to be an under-reporting of the delegation occurring overall in this facility, as procedures such as fluoride varnish and scale and polish, which are traditionally delegated, were not available for analysis in this main extract. However, the data gave a good indication of delegation of the higher level tasks within the scope of hygiene-therapists' practice. The findings, do share similarity with the ADHS (2009), where 52% of patients who managed to see a dentist also saw a hygienist or hygiene-therapist.

From the main extract analysis 46% of the high level procedures that could be delegated were delegated to HTS. Other procedures such as fluoride varnish and scale and polish, which are traditionally delegated, and were investigated through supplemental data, were found to have been delegated at 91% and 92%. These findings do compare broadly with those of Evans et al. (Evans et al., 2007), who suggests that 35% of care visits and 43% of clinical time could be delivered by trained dental hygienists and therapists.

In the first year of the establishment of the UPDA the rate of delegation of tasks was 46.8%; in the second it was 46.2%. The drop although slight was considered carefully. It was found that the clinic arrangement changed in the second year. While the DS and HTS were still in teams, they were located in different clinics in the second year. Parallel research on-going at UPDA on the qualitative aspects of team training suggested that students felt less likely to delegate tasks when they were placed in separate clinics (Colonio-Salazar, 2014). Colonio-Salazar (2014) further stated that students go through a transition where they feel they should work exclusively then inclusively, which is followed by improved self-esteem, utilisation and appreciation of other

members of the dental team (Colonio-Salazar, 2014). Further research is required to explore reasons for delegation and non-delegation of patient care.

#### **9.4.2 Age-specific delegation rate**

The high rate of delegation of children (85%), compared with adults (50% of 18-64 year-olds and 54% of ≥65 year-olds), could be attributed to a number of factors. First, the more widely accepted and traditional role of the dental hygiene-therapist in children's care, since the first dental therapists were introduced to work in school dental services in New Zealand (Kravitz SA and Treasure, 2007), and the perception that those with therapy training are well suited to caring for children has persisted (Nash et al., 2008, Nash et al., 2014). Second, the need for students to gain certain clinical experience may have played a role; dental hygiene-therapy students have the opportunity to treat children at UPDA only, whilst dental students do so in other settings. This is important as they move forward in their careers as various studies suggest there are gains to be made in patient outcomes and productivity, through their utilisation in children's care (Wang, 1994, Bailit et al., 2012). It would have been beneficial to analyse control for the type of care and rate of delegation. However, due to the cross-sectional structure of the data set it was not possible to undertake that analysis.

Moving on to the rationale for the delegation rate of adult care, the lower level of delegation amongst adults may be attributed to a number of factors. First, scale and polish, a common component of adult care was not coded by the provider of care and therefore could not be included in the analysis. This may have reduced the potential for a large number of adult patients who had been delegated for that procedure from being included in the analysis. Second, adult patients may have required more complex overall care, therefore necessitating the additional knowledge and skills of a dentist. Third, dental students at this level need experience of more complex procedures, e.g. endodontic treatment, fixed and removable prosthodontics, and so may be more selective in focusing their clinical time on complex tasks required by patients and delegating routine care.

Another interesting aspect of these findings is the high proportion of preventive procedures outside of scale and polish delegated to HTS. This is a positive finding as it is important for hygiene-therapists in training to have experience in performing tasks that could be useful in



targeted schemes for prevention. Other studies have shown that dentists are more comfortable delegating preventive procedures as they favour the idea that DCPs have less time constraints (Nilchian et al., 2009). The delegation pattern for a range of restorative tasks that can be performed by both dentists and dental hygiene-therapists, but notably, not as widely performed by hygiene-therapists in practice (Jones et al., 2007a, Godson et al., 2009) were also shown to be delegated at a rate above 50%. This raises the issue of whether this the best use of expert trained dentists.

The supplemental data analysis indicated that the rate of delegation of scale/polish and fluoride varnish was over 90%. This was an expected finding; as mentioned earlier, it has been evidenced that dentists are comfortable delegating preventative tasks (Jones et al., 2007b, Nilchian et al., 2009). However this may not be a major concern as the dental students involved with outreach are in their final year and so have been taught the delivery of such care in the preceding four years of their education at dental school.

In this study, a significantly higher proportion of smokers was delegated to HTS. The reasons for this are unclear; however, it is apparent that these HTS students were presented with an opportunity to provide health promotion with regard to smoking. This pattern probably reflects that fact that smokers were overall needing and receiving a higher proportion of preventative care, as has already been discussed. Studies have shown that dentists and hygiene-therapists have been able to provide useful help in smoking cessation advice (Dyer and Robinson, 2006a, Gordon, 2007). The role of the whole dental team in health promotion has been widely discussed, particularly in relation to promoting oral health among underserved groups (Watt et al., 2014). This experience with health promotion activities is important in their development as health care professionals. At present, the students are required to signpost only patients identified as smokers to cessation services. It may be appropriate to expand prescribing roles for DCPs so that they can fully undertake smoking cessation advice to patients

This study sheds light on the experiences gained by both dental students and hygiene-therapists when trained together and could provide insight into their future pattern of practice. Although the study has limitations due to the inability to analyse all procedures together in the main extract, only in the case of the supplemental analysis for scale/polish and fluoride varnish

it does gives insight into a less commonly delegated group of procedures when it comes to skill mix use such as pulpotomies and tooth restoration. It is, however, important to consider these findings in the light of the fact that the UPDA is an educational facility and learning needs may have played a part in the practice of delegation. However, it shows the nature of experience these students are gaining and are likely to carry forward into their practising lives worth 40 years. The results of this skill mix analysis show the influence of the nature of the task and the age of the patient in the delegation rate thus providing a helpful insight for the operational research modelling.

## **9.5 Alternative scenarios for skill mix in England**

### **9.5.1 Introduction**

The operational research model advances knowledge by quantifying possible contributions of hygiene-therapists to the provision of primary dental care in England. The results highlighted that that majority of clinical time in NHS dentistry spent on tasks within the jurisdiction of hygiene-therapists. The findings of the scenarios in this part of the research are a culmination of the understanding built from the earlier case study results that show patients who are attending primary care services expressed a pattern of treatment need. Understanding these patterns can aid in gaining definitive detail on how treatment can be provided using skill mix and how this can be improved using evidence-based practice. In the following sections each of the scenarios results are discussed for the implications to skill mix use in primary dental care in England.

### **9.5.2 Overall clinical time and treatment: Base model findings**

The outputs of the base model, which showed the number of clinical hours required to perform all the treatment demand experienced in NHS primary dental care in England within the year 2011/12 based on the validated Heathrow timings indicated that only 23% of clinical time was spent on dentist only tasks. This provided evidence of the jurisdictional claim between dentists and dental hygiene-therapists, highlighting a huge overlap and potential for skill mix. The findings also indicated which treatments and patient groups accounted for the most clinical time. Work time studies have been shown to be useful in ascertaining the most time-consuming tasks or patient groups in public dental services (Swedberg et al. 1993, Wang 1994, Swedberg 1995). The results of the model compare with previous studies, where diagnostic tasks have been

shown to consume most clinical time. In this study these represented 34% of clinical time, of which 86% of the diagnostic tasks' time was spent undertaking examinations and care planning. This finding is similar to work undertaken by Evans et al. (2007) in Wales, who found that diagnostic procedures were the most time consuming. The time taken for diagnostic tasks presents as very relevant to the skill mix debate, as the regulation changes have evolved slowly when considering DCPs as the first point of contact. Now that direct access to DCPs is allowed, the potential to save the majority of time through delegation of these tasks is shown to be large, as suggested by this model.

As more evidence is generated regularly on the reliability of DCPs diagnostic skills (Macey et al., 2015), the challenge lies in the dissonance between regulations from different bodies as highlighted in the literature. This is in reference to the NHS policy that does not allow DCPs to hold performer numbers and claim for NHS care, which contrasts with GDC direct access regulation (Howe, 2014). Considering the present evidence that the majority of care in the NHS can be undertaken by DCPs, this is a glaring mismatch. There is likely to be more debate around these issues which may hasten changes, as the new dental contract pilots care pathway has already been criticised as time-consuming due to the comprehensive examinations (Department of Health, 2012c). There is therefore potential that diagnostic tasks will take even longer and there is room to consider how these tasks should be shared with relevantly skilled dental team members effectively and efficiently.

### **9.5.3 Overall clinical time and age**

The base model demonstrated that the amount of clinical time spent on each patient age group varied. Patients aged between 45-54 years were the most time-consuming group (16.2% of all clinical time). The children's clinical times were all lower than adult times and only compared with over 75-year-olds who required only 6% of all the clinical time. Several studies have indicated the variation in care in different age groups (Fitzpatrick, 2000, Locker et al., 2004, Milsom et al., 2009). These results contrast with findings by Swedberg et al. (1993), almost 20 years ago in Finland, who found that 13-19 year olds were the most time-consuming patient groups for the provision of dental care. This difference in this study may be an indication of the shift in the oral health profile in populations in Europe, with an increased need for complex treatments which take longer in these middle-aged groups. Other studies have shown that

amongst children, overall clinical time can be reduced by increasing skill mix and recall intervals (Wang 1994). The base model gave an ideal sense of the amount of time required to meet demand and provided a foundation to understand how delegation for each scenario impacted on the overall clinical time shared.

#### **9.5.4 No skill mix 'dentist only'**

The first scenario simulated as 'no skill mix' proposed that dentists undertake 100% of care. This scenario, when analysed, suggested that 12,685 WTE of dentists would be required based on the operational modelling parameters. However, if the national working patterns as ascertained by Robinson et al. (2011) were applied, there would be a need for 24,736 dentists. Based on the NHS Information Centre (NHS Information Centre, 2012), 22,900 dentists performed the tasks modelled in DENTASSim. There is no information on how many DCPs were involved and to what extent these findings seem to be plausible; this would suggest either 1,826 additional dentists or that there was some skill mix in NHS care. In relation to current workforce numbers, this number falls short of the total number of dentists who are (30,447) registered in England and does bring into focus that if there were no DCPs the number of dentists present would still not need to increase. This supports the recent report from Health Education England that proposes to cut down the intake of dental students and increase DCPs' intake gradually (NHS Health Education England, 2015).

#### **9.5.5 UPDA as a national model**

Scenario 2 UPDA National' simulated the possible skill mix requirement in clinical hours and WTE, if the model of practice in UPDA was adopted nationally. According to the model this would lead to 29.5% of all clinical time undertaken by hygiene-therapists. A comparable study in Norway from dentists' self-reports outlined that they spent 40% of their time on tasks that hygienists could also perform (Abelsen and Olsen 2008). More recent work in England, although not directly comparable, suggested that hygiene-therapists spent only 40% of their time undertaking therapy tasks (Robinson et al., 2011). This suggests a higher delegation rate from the UPDA model or higher rate of skill mix use. These findings, when applied to economic evaluation by salary costs, suggests that 19% savings could be achieved in this model compared to a no skill mix model. However, this would require an increase in the number of DCPs or an increase in the working hours over the 0.3WTE estimated following Robinson et al.

(2011) reports. Due to the high propensity for career breaks for DCPs (Gibbons et al., 2000), it may be worth considering that more training places for DCPs is the more practical long term plan.

#### **9.5.6 Direct access**

It has already been suggested in Section 9.5.2 that diagnostic tasks take up a considerable amount of clinical time, and with direct access, this time could be shifted to DCPs. Direct access may be a key part of the practice of NHS dentistry and Scenario 2 'Direct Access' explored this eventuality. As there is little evidence of the impact of direct access, the DENTASSim operational model simulated the outcome of the delegation of a proportion of examinations to hygiene-therapists as would be in the case of direct access. The results indicated that if 30% of clinical examinations were performed by hygiene-therapists, 3% of clinical time would have shifted from dentist to hygiene-therapists and at 70%, an almost equal dentist to hygiene-therapists WTE ratio would be needed to meet total demand. Direct access could free up the time of dentists to perform other tasks. This is especially significant as the indications that the 45-54 year-old age group years are requiring complex treatments which constitute more time. It may be useful to monitor how demand for care within this age group progresses to ascertain how much more clinical time should be freed up over the years to meet changing demands. There is currently no data on the likely clinical time-saving of direct access in NHS primary care, and this data advances understanding of how clinical time can be shared effectively.

The model overall clinical time when applied to clinical working patterns as established by Robinson et al. (2011), suggests that the proportion of NHS dentists could be reduced by more than 50% if examinations (direct access) were transferred to hygiene-therapists. The recent CfWi report on DCPs suggested that if there was 18% direct access by 2025, this would require 7,700 FTE hygienists and 2,000 WTE therapists (Centre for Workforce Intelligence, 2014b). These figures compared with the findings from this study that suggest a similar direction, with a need for increased numbers of DCPs with direct access of 20% estimated to lead to a need for 4,663 WTE hygiene-therapists or equivalently trained individuals in this research. The difference between CfWi's work and this research is that they do not factor in treatment specific demand, or time for treatment, and their data is based on numbers of personnel and age group estimated

attendance patterns. Also delegation is estimated through expert opinion which varies and is not as definitive as measured delegation, thus their findings are potentially less robust.

It was interesting to find from the results of the current study that if 50% direct access was instituted in all age groups, children's proportion of clinical time would overwhelmingly be undertaken by hygiene-therapists. For example, for 3-5 year-olds, whose overall clinical time according to the base model was 2.4% of all clinical time, the delegation of examinations to DCPs would lead to 62.5% of their care being undertaken by the hygiene-therapists. For the whole expressed treatment, 44.6% of total clinical time would be undertaken by the hygiene-therapists with 50% direct access arrangements (examinations delegated); while maintaining the same delegation rates as UPDA for all other clinical items. These findings suggest that more time would be available for dentists with direct access.

A systematic review by Turner et al. (2013) proposed that direct access would increase capacity and is likely to improve provision of dental health, but also suggests over referrals may occur and ineffectively utilise dentists' time. Other commentators propose that more training for DCPs can help reduce over referrals and highlight that patient satisfaction is high in direct access arrangements (Innes and Evans, 2013). Brocklehurst et al. (2014) suggested that there was not enough information on the effects of direct access in the UK, and in 2015 Macey et al. recently reported that hygiene-therapists were just as effective as dentists at screening patients for dental disease.

According to the literature, cost has had an influence on the stagnation of skill mix use. A crude cost-minimisation analysis of the implication of direct access on the salary costs was undertaken. Cost minimisation is a technique that looks for the lowest cost alternative of two where the outcome is considered to be the same (Neale 2009). The analysis indicated that at a 70% rate of delegation of examination 13% of the salary costs could be saved, and at 50%, 7% salary cost saving could be made, while maintaining the delegation rates of UPDA for other treatments. There are of course other factors to be considered when skill mix is used, which may weigh in such as estate costs (Harris and Sun 2012), but salary cost analysis does provide an encouraging prospect on how a component of cost can be saved. Other studies have indicated that a 3% saving could be achieved through the inclusion of therapists in primary care

practice (Linna et al. 2003), however, the current analysis specifies what aspect of care and skill mix proportions could lead to the mentioned cost savings. And from data that has suggested that NHS dentistry costs £3.4 billion (NHS England 2014), the findings in this study that suggest that minimal direct access will lead to average salary costs of £560,534,540, would appear to be an affordable alternative.

As the debates on direct access will continue in England by both proponents and detractors (British Dental Association, 2012, Holden, 2012), there continues to be a critical requirement for researchers to fill the vacuum of data and this study has significantly contributed to that purpose.

#### **9.5.7 More prevention and DCPs**

Scenario 3 'more prevention' is a scenario that is built on the premise of the possibility of greater preventive care in the future. It particularly introduced the evidence-based recommendation for fluoride varnish for children (Public Health England et al., 2014). In the year 2011/12 the demand for fluoride varnish, shown in the model, constituted 13.1% of treatment plans undertaken on children (Health and Social Care Information Centre, 2012). This scenario simulated an increment in demand for fluoride varnish to between 20% and 100%. The findings suggested that with a 91% delegation rate of fluoride varnish to hygiene-therapists only an extra 465 WTE hygiene-therapists and 45 WTE dentists would need to be added and this translated to a 1% increase in salary costs. This is the first analysis on possible outcome of increasing fluoride varnish based on recommendations and with the use of skill mix. This relates back to the points highlighted in the literature regarding how skill mix can contribute to effective health promotion strategies. This is worth considering as it has been highlighted that there is room for long-term improvements in oral health as a result of prevention, which would lead to cost savings (Yee and Sheiham, 2002). There is room to investigate other procedures such as fissure sealants and how this can impact on skill mix use.

#### **9.5.8 Maximum delegation**

Maximum delegation in the context of this scenario was underestimated. It applied 100% delegation of some treatments to DCPs': examinations and prevention, and 50% delegation of contested care: radiographs and tooth restoration. The results suggested that 62.8% of clinical

time could be delegated in this scenario. This provides room to consider how much more of DCP's skills can be utilised to meet the changing demands. It appears that the majority of the demand in primary care is within their scope. As evidenced from other analysis in this research and the adult dental health survey, the proportion of care involving complex treatments and routine care is increasing in older adults and younger adults respectively and a scenario where more clinical time is within the jurisdiction of DCPs is likely.

In addition, the scenario applied to cost-minimisation analysis indicated that a 52% salary cost saving is possible with this arrangement. There are implications to the workforce with these findings, as according to the WTE generated by the model and the working patterns described by Robinson et al. (2011), there would be a need for 20,365 hygiene-therapists. Presently there are 2,128 hygiene-therapists and 5,462 hygienists and some of the hygienists are dually-trained and registered under both professional groups (General Dental Council, 2015). It is therefore realistic to estimate that on the lower side, if hygienists undertook some of the tasks, there would be a need for at least four times the number of hygiene-therapists and/or hygiene therapists. Other alternatives would be to enhance the roles of nurses to undertake preventative tasks which constituted 18.4% of clinical time. This would lead to even higher salary cost savings. Finally, the amount of time the hygiene-therapists spend undertaking NHS clinical care, if increased from 0.3 WTE, could substantially reduce the number of new personnel required. It must, however, be noted that these figures are based on maintaining the demand and working rates described in DENTASSim model, of which either could increase or decrease. There would be a benefit in undertaking futures scenarios in order to factor in the changing patterns.

The operational research findings suggest that including demography, task sharing and time as predictors of demand on dental services, the clinical time and workforce requirements can be identified to the detail of patient group and treatment. When these aspects of demand are altered to reflect reorganisation of working relationships based on regulation changes that improve autonomy and jurisdiction (direct access) of DCPs such as hygiene-therapists, learning can be gained on the distribution of clinical times and WTE. The model is flexible and can allow practice level modelling by use of practice data.



By applying the model of delegation at UPDA to the whole of England, the data showed that there would be room to expand the roles of other DCPs such as hygienists and nurses with extended duties. The CfWi has already suggested that by 2040 there will be an oversupply of between 1000-4000 dentists in England and an increase of DCPs if direct access is to be enacted. But the likelihood that the demand for complexity of care will increase is indicated by the relationships revealed in the study of predictors of expressed treatment needs. With predictors of demand such as ageing and increased patient expectations it is important to free up more time for dentists. The results demonstrate the feasibility of delegating and increasing the time available for complex care.

From NHS Information Centre reports for the year 2011/12 a total of 22,920 dentists performed all the primary dental care excluding orthodontics (Health and Social Care Information Centre 2012). From another survey report of working hours for dentists in the same period, it is detailed that dentists spent 74% of their time on NHS dentistry, of which 18.3% was on non-clinical work (Health and Social Care Information Centre 2012a). In addition it is stated that they would spend 4.5 weeks on average annual leave. From this, it is possible to ascertain the WTE for the dentists but we cannot establish how many DCP's were involved in this care, leaving room for questions regarding whether a DCP should have performer numbers to allow this information to be documented and for better planning of their roles.

#### **9.5.9 Scenario findings and education**

The implication of the scenario findings can translate to education and training and professional growth for DCPs. In essence the findings suggest the benefit of training more DCPs if more prevention is to be undertaken and if time is to be made available for future complex care; this is similar to the recommendation made by CFWi (Centre for Workforce Intelligence, 2014b). It is clear that there is a need for more data in order to accurately predict how much time DCPs are working, but the findings from this skill mix analysis gives a good base. Some forthcoming issues translate back to the roles of DCPs and their personal development as a professional group. Sanglard-Oliveira et al. (2012) argued that for a group to be considered a professional entity they need to be able to control their own work and this relates to autonomy which is legitimised by society and regulated (Freidson, 2001). For DCPs in England, the public have been accepting of their roles, as individuals have cited 'trust' of the dental professional as more

important rather than whether they are DCPs or dentists (Dyer et al., 2013). With regulations supporting their expanded roles, the work environment is the only area that needs development in order to grow the roles of DCPs.

Wake (2014) points out rightly that the direct access plans only facilitate better working within general practice and does not signify opportunities to setup rival practices against dentists, as several other elements of patient care are still regulated under other authorities such as the prescribing of emergency drugs etc. It is, however, a challenge for general practitioners who are practice heads as they are the ones who hold performer numbers, to envisage the benefit of including DCPs in care. Bullock and Firmstone (2011) highlighted that perhaps one of the bigger challenges for skill mix development in primary care is the large number of GPs who are likely to close ranks. As the question of turf wars is a pertinent one when attempting to rearrange traditional boundaries of professionals (Pinder et al., 2005), for any substantial debate, ethical and economic arguments can be presented, based on research such as this. In terms of ethics, for those who subscribe to the theory of equity in health, such as egalitarian liberals or communitarians, the potential for quality care being equally divided through prevention and synergy in the practice of DCPs and dentists has been demonstrated. Equally there is a potential cost saving, although this does not encompass all aspects of cost, but the opportunity to redistribute resources based on savings from one domain such as salaries is encouraging.

The next step for dental therapists and other DCPs is appropriate education and training to fulfil the range of tasks that prevailing needs of the population are demanding. More work is required to estimate how the change in needs is progressing through the years and how education numbers would need to change. Presently, there is already a drive to reduce training for dentists by 10% and increase dental therapists training spaces (NHS England 2014). More research to guide this process is required.

#### **9.5.10 Other approaches to skill mix research**

The findings from this research have demonstrated the potential for skill mix in dentistry by exploring both workforce numbers and evidence based practice. This work advances the research in the field by first looking at the whole patient population in comparison to past work that has focused on older people's oral health needs and demand (Gallagher et al. 2010). The

work differs from on-going studies which are focussing on technical efficiency and specifically the production of the maximum amount of output from a given amount of input (Brocklehurst et al., 2013), in that it not only explores both production of outputs using a skill mix oriented workforce but provides a further shift towards evidence based prevention. This work, however, does not ignore the economic implication of skill mix as it includes a salary cost minimisation evaluation to the work because of the recognition of the importance of the business model in dental practice (Harris and Sun, 2012).

The inclusion of evidence based practice can be argued as the way forward as national health services are becoming more geared towards patient centred care in an attempt to achieve better outcomes (National Health Service, 2014). It is therefore reasonable to consider that any health care team should be planned with this aspect in mind. It can be argued that this research also provides evidence of a wider view of efficiency, not merely technical efficiency, by proposing that patient outcome improving activities should be considered as 'outputs'. And as Harris and Sun (2012), propose, the concept of outputs should be considered with better clarity.

#### **9.5.11 Contribution to Interprofessional training literature**

This study has furthered the research around interprofessional training by investigating an the implication of team training to the sharing of clinical tasks and contributes to understanding the practical interaction between dental students and DCPs. This is an aspect other than soft skills such as communication and confidence which is more commonly investigated (Morison et al., 2011, Morison et al., 2008, Morison and Jenkins, 2007). This responds to questions raised by other researchers on improving the research on the impact of interprofessional training on hard skills in both the undergraduate environment and beyond (Reeson et al., 2013). The study reveals vertical task sharing as described by Reinders and Blanksma (2012). The study would, however, benefit from a comparison with another group not involved in interprofessional training, such as the other half of the dental students who did not attend UPDA.

#### **9.5.12 Use of patient management data**

Patient management system data were used in this research. There were benefits and challenges in the use of these data. First, although the use of these data requires extensive data cleaning procedures, they provide the opportunity to overcome recall biases, low response

rates and social desirability biases which are common in surveys (Marshman et al., 2012, Choi, 2012, Guiney et al., 2013, Murakami et al., 2014). Validation of the data was important and was an ongoing process, and some of the findings received from analysis of treatment activity were useful in indicators of the validity of the data. For example, the trend in the starts of new treatment plans was higher in the month of September (when the Academy had dental students starting). In fact, the highest number of treatment plans started within the four-year study period was shown to be in the month after the facility was expanded. These particular results were useful in validating the data obtained, because these were expected patterns, and this matched over with billing data provided for contractual purposes. This is a recommended method of validation (Kudryakov et al., 2012).

UPDA's patient management system was developed mainly for administrative functions, in this research it was, however, used to provide information of treatment rates and patient socio-demography. In many cases these type of data have been used in research on treatment rates and are telling of the demand and useful for health service planning (Schwarz, 1996, Guiney et al., 2013). In many studies insurance data bases, both private and public, have been used to ascertain the trend in need. These data are useful, but rarely provide detailed information on the patients, i.e. social status, smoking status etc., as was possible with the UPDA system. Claims data have information which is only necessary for the payment of treatment. In the case of this research, the additional information on patients' details allowed augmentation to census data, providing a contextual understanding of the patient groups. These types of data are non-invasive and save time from surveys or use of structured data collection processes where a specific clinician would have to collect data (Topping et al., 2005).

Of particular importance was that the software used in UPDA is the same as that used widely in general practices in the UK. This is relevant as the research findings could find generalizability in general practice. The understanding of wider determinants of oral health from the augmentation of the UPDA data, adds strands of information on where to increase emphasis on health promotion. Although there were several challenges in obtaining data from the patient management system, the potential to obtain a wealth of information lies in structuring plans to improve how these systems work and store data.

### **9.5.13 Summary of the discussion**

The evidence of these professionals working in a primary care environment gaining experience with the range of needs in the society is evidence of an educational strategy that is preparing these professionals appropriately. For patients, the free services have increased availability. With the changes that are forthcoming in general practice in the NHS, which will be the first stop after training, the dental team experience at the UPDA will have a good working knowledge of how to work together.

The obvious evidence of variations in needs are worth added consideration when planning for population weighting as in the new dental contracts. In addition, the role of skill mix in promoting health by undertaking prevention tasks such as fluoride varnish or in high risk patients such as smokers is significant. Commentators on the direct access likely outcomes are suggesting that more training is required on assessments and perhaps more so on helping change behaviour using the common risk approach. Turner et al. (2014) particularly highlighted the need to improve chronic management skills of DCPs for direct access.

Finally, as plans are made for the future workforce, careful consideration should be made of the patterns of expressed needs/demand and how skill mix can be distributed distinctly within the different need groups and tasks.

### **9.5.14 Limitations of this research**

#### *Data*

The data were cross-sectional and this is known to be associated with some research design biases, namely selection bias, which may exclude patients due to the time span from which the data was obtained; in addition causal inferences could not be made due to lack of knowledge of which variable parameter came first. To mitigate this, a wide study period was selected, with criteria that ensured a large and representative sample of patients was obtained. Unfortunately an analysis of yearly trend in treatment was not possible due to the cross-sectional data, but description of the completed plans in the period was possible due to date stamp variables, which were only available for completed or started. Longitudinal data would have been helpful in

providing information on causality and giving direction of associations between variables. In addition, if the particular treatment groups of data could be recorded in different tables, it would have facilitated regression analysis that controlled for each treatment. For example it would be beneficial to ascertain whether receiving prevention and restorative care in the same course of care has a significant implication on delegation or the type of care received.

The second limitation associated with data was the breadth of data available in the patient management system. Information of risk profile of patients would have ensured outcomes were factored into the nature of treatment need, however because these data were poorly populated this analysis could not be undertaken. In addition, as the coding within the patient management system did not include provider-coding for procedures such as scaling and polishing and fluoride varnishing this made it difficult to estimate the delegation for the whole group of procedures within the hygiene-therapists jurisdiction. It was however possible to do so for a number of high-level treatments.

Third, in terms of skill mix analysis, it would have been useful to have more provider related information in the patient management system to analyse; such as year of study. In addition, timing of procedures would have been a good inclusion to the data collected, however, due to the educational structure which may involve longer than normal treatment times for procedures, any timing at UPDA could not be applicable on a national scale.

#### *Study site*

The design is also based on a single site and often this design is challenged. That said, single site studies are valid, as they provide an opportunity to undertake in-depth investigations on the phenomenon as it occurs naturally. Although generalizability of findings is a common limitation, to mitigate these, robust protocols and validating criteria prescribed by experts in the field of research were adopted (Yin, 2009).

#### *Study design*

It would be helpful to have obtained information from patients regarding why they received certain treatments i.e their perception of needs. In the same way information on the reasons why the patients chose to attend UPDA would be helpful.

The operational research model was able to provide definitive results on distinct scenarios, however, it would have been useful to have included other variables in the model; the issue with this was that there was not enough data on parameters such as deprivation by treatments which is discussed at length at the start of Chapter 8. There would be value in undertaking futures work and projecting various additional evidence based practice scenarios and the use of skill mix.

## **9.6 Conclusions**

### **9.6.1**

This research demonstrated that in this primary dental care training institution a broad section of the societal spectrum presented in the four-year period surveyed; however, following expansion to include dental students in team training with dental care professional students, the service became free at the point of delivery, with increased capacity for the delivery of complex care, patients who accessed in the initial period were older and less deprived, with a significantly higher proportion of adults that would normally have to pay charges when compared with the period before.

### **9.6.2**

In this primary care service where services are free at the point of delivery and patients are involved in treatment plan decisions, the research suggests that there was a strong association between socio-demography of patients and the treatments received. Most notably, the findings provide evidence of an increase in need for the most common treatments among adults with increasing age and smoking. Similarly, there were significant differences in gender when tooth extractions and tooth restorations were examined, males being more likely to receive these treatments in this facility. More deprived patients received advanced treatments such as extractions when compared with less deprived patients, however, payment exempt adults were more likely to receive instructions and advice on oral health than their counterparts.

### **9.6.3**

In this primary care environment where students trained as a team the majority of patients who received treatments had undergone care from hygiene-therapists at least once. Dental students delegated patients from all demographic groups; however, children and adult smokers were delegated at a significantly higher rate than adults and non-smokers. Preventative tasks were more commonly delegated than restorative tasks. In analysing individual treatments, within the limitations of the coded data, fissure sealants were shown to be delegated at a significantly



higher rate for females, whilst tooth restorations were delegated at a significantly higher rate for children and smokers.

#### **9.6.4**

There are implications for an increased multiprofessional workforce in primary dental care. Based on the evidence from the model, there is potential to free up more time, increase prevention with minimal cost implication, save money through direct access and delegation of routine tasks. These alternative scenarios would require educational plans that increase the number of dental care professionals and/or expand the roles of some of the other dental professionals such as nurses; while dental students' intake numbers could be decreased.

#### **9.6.5**

This research demonstrates that patient management systems may provide verifiable accounts of patients and the care they received facilitating a wider learning predisposing factors to a variety of health care needs and who can contribute to care. There are limitations to use of these data, related to the access to diagnostic information and longitudinal information, which is often overridden; however, if these data can be better stored with consideration of use in research and epidemiology they would aid in better understanding of the patients' baseline conditions and progress through the dental care process

## **Chapter 10 Recommendations**

### **10.1 Primary dental care**

#### **10.1.1**

The working patterns of DCPs should be monitored and this can be undertaken by encouraging the inclusion of provider codes in patient management systems, so as to identify who undertook which care. This will aid analysis of skill mix patterns.

#### **10.1.2**

Monitoring of the patient base regularly using information systems could outline whether the higher needs patients are having an opportunity to be treated.

#### **10.1.3**

When establishing new dental services inequalities in access should be considered and channels parallel to dental helplines should be used to avoid discouraging hard to reach groups from access.

#### **10.1.4**

Training professionals as a team should be recommended to improve teamwork.

#### **10.1.5**

Hygiene-therapists and hygienists should be provided with NHS performer numbers to encourage their work in the NHS and to aid monitoring of their contribution to care.

### **10.2 Dental technology**

#### **10.2.1**

Databases for dental patient management should be modified to allow storage of longitudinal data to improve the quality of the research that can be undertaken using these type of data.

#### **10.2.2**

Patient management systems could have coding that shows the provider of care allowing labour outcomes of skill mix to be analysed.

### **10.2.3**

Non-identifiable demographic, educational and social details related to the providers of care should be tagged on to patient management software, allowing these data to be linked to the care provided and facilitate analysis of practising routines.

### **10.2.4**

Dental practices can use an operational model within their environment to ascertain the ideal skill mix based on the demand in their practice.

## **10.3 Future research**

### **10.3.1**

The time taken to provide care should be researched in different settings of primary care to allow accurate modelling of clinical time requirements.

### **10.3.2**

Studies that ascertain average care by the complexity of a patients treatment needs should be developed in order to ascertain the potential clinical time consumed for certain patient case-mix

### **10.3.3**

The differences in work quality and time taken for care between dentists and mid-level providers should be researched and compared to different years of experience to ascertain how experience would have an impact on the rate of activity.

### **10.3.4**

Study to investigate delegation practices of dental professionals based on experience, training, and social characteristics.

### **10.3.5**

Applying DENTASSim to retrospective demand in another single site practice to ascertain the applicability of the model in planning services using DCPs.

#### **10.3.6**

Analysis of demography-specific demand changes based on NHS BSA data and workforce changes across several years to estimate the yearly change in workforce skill requirements using futures modelling.

### **10.4 Implications for practice**

#### **10.4.1**

This study provides potential ways to model requirements for practice of the dental team, simulated on actual expressed demand for treatment and this can be replicated on a sliding scale between smaller and larger practices.

#### **10.4.2**

The use of patient managements coding provides an opportunity to understand and evaluate the use of skills within the dental team and the nature of care provided and patients treated.

#### **10.4.3**

The patient management systems have allowed the evaluation of relationships between social and contextual characteristics and expressed treatment need, and this information can be useful for targeted programmes.

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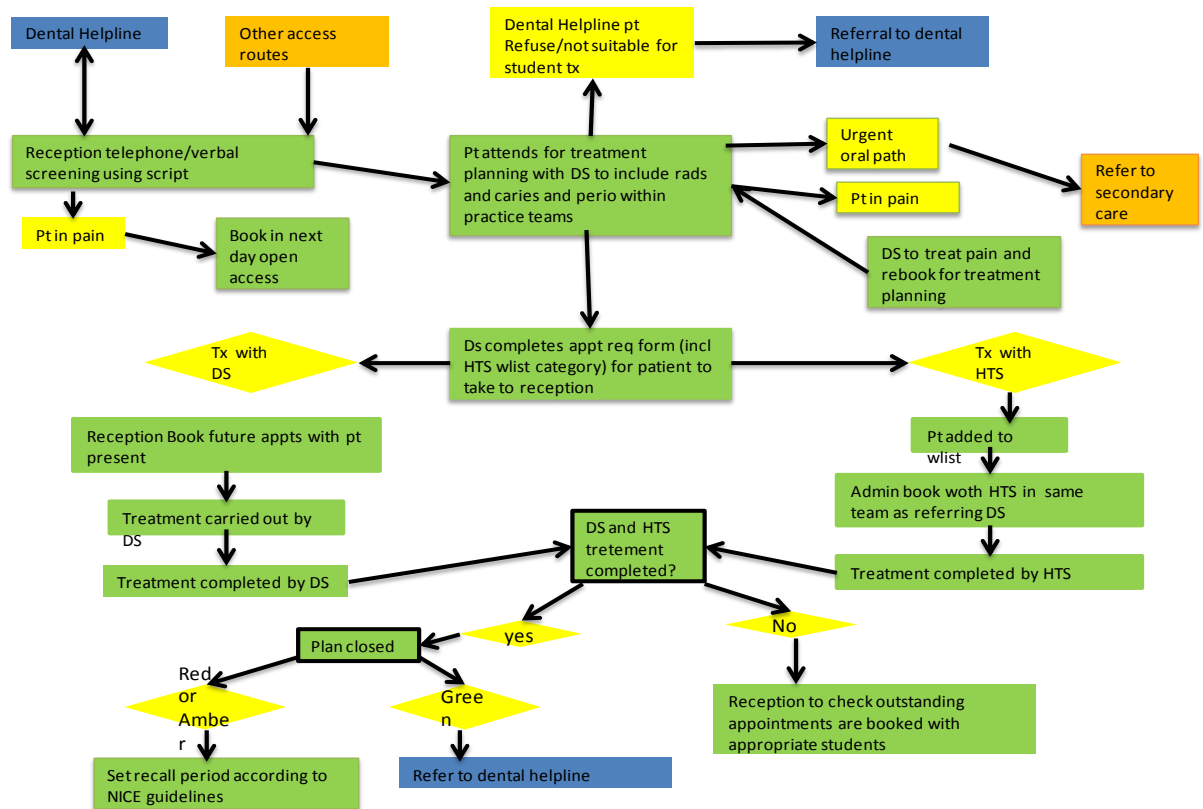
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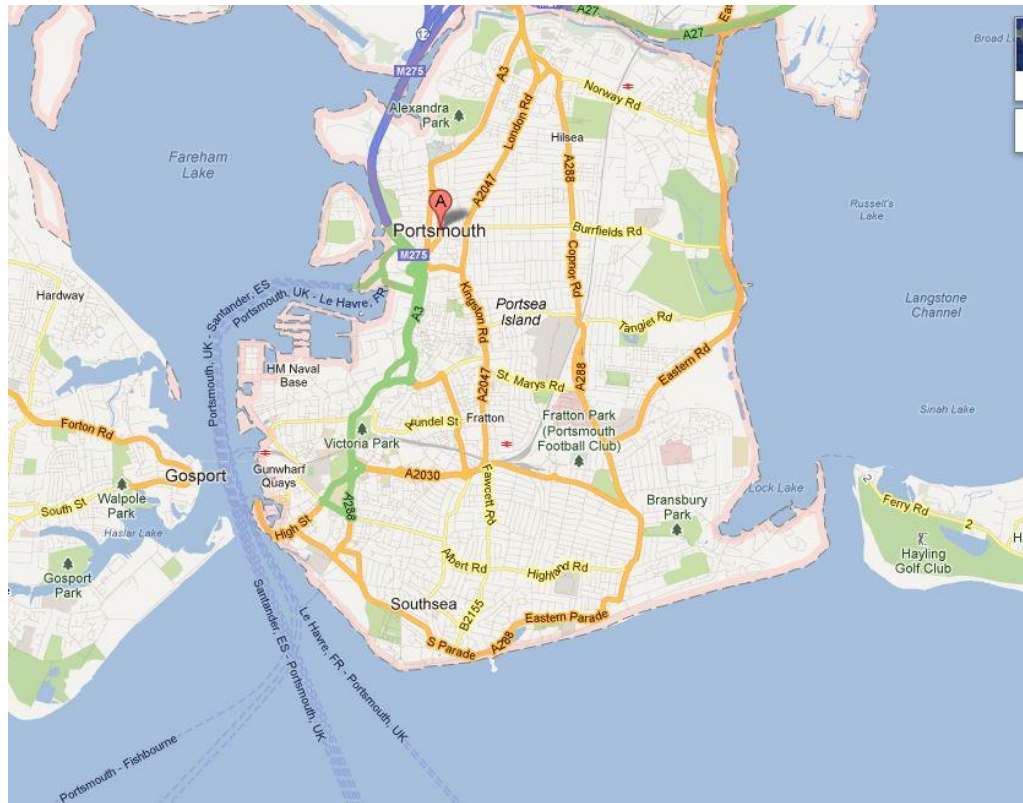
## 10.6 Appendices

### 10.6.1 Appendix A: Patient care pathway at UPDA





## 10.6.2 Appendix B: Map of Portsmouth and environs



### 10.6.3 Appendix C: Mind map for literature review



#### 10.6.4 Appendix D Electronic search

Database: Books@Ovid <May 15, 2015>, Embase <1974 to 2015 May 15>, Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) <1946 to Present>, PsycINFO <1806 to May Week 2 2015>

Search Strategy:

- 
- 1 (dental or dentistry).af. (1211512)
  - 2 (skill mix or skill-mix or delega\$ or task shift\$ or role substitut\$).af. (24417)
  - 3 (primary care or health servic\$ or dental servic\$ or primary health care or primary dental care or NHS).af. (1649420)
  - 4 (dental workforce or mid-level providers or dental team or dental teamwork or teamwork or health workforce).af. (42800)
  - 5 (oral health need\$ or health need\$ or health demand\$ or oral health demand\$).af. (31140)
  - 6 1 or 2 or 3 or 4 or 5 (2862135)
  - 7 (United Kingdom or England).af. (11599055)
  - 8 6 and 7 (901463)
  - 9 (skill-mix or access) and delegat\$).af. (1176)
  - 10 remove duplicates from 9 (932)
  - 11 manual review (77 )

## 10.6.5 Appendix E: Some relevant Themes related to skill mix

	<i>Sub-themes</i>	<i>Supporting literature</i>
<b><i>Outreach training promotes team based model of care</i></b>	<p>The development of professional self-confidence among the students was an opinion shared both by students and tutors.</p> <p>The exposure to- and experience with clinical team-work was emphasised as very beneficial</p> <p>Community based dental education also provides dentistry with an opportunity to guide dental faculty and student values and orientation towards public service, engagement, ethics, and the health of the public.</p>	(Smith et al., 2006a, Smith et al., 2006c, Smith et al., 2006b, Eriksen et al., 2011, Mofidi et al., 2003, Strauss et al., 2010)
<b><i>Team based model of care</i></b>	<p>Team work in dentistry is needed</p> <p>Skill mix is the future</p>	(Nuffield Foundation, 1993, Department of Health, 2002a, General Dental Council, 2006, General Dental Council, 2011)
<b><i>Oral health needs influence skill mix required</i></b>	<p>Ageing population may require more dentures and domiciliary work</p> <p>Children requiring preventive services and treatment may be better served by DCPs and skill mix</p>	(Gallagher and Wilson, 2009, Kleinman et al., 2009, Gallagher et al., 2010) (Nilchian et al., 2009, Nilchian et al., 2011)
<b><i>Potential for delegation of duties within skill mix</i></b>	<p>Delegation of duties from dentists to DCPs could lead to increased productivity, dentist time would be saved, and cost could be saved, improved health promotion activities efficiency.</p> <p>Patients are not fully aware of DCPs role but welcome they care and are satisfied</p> <p>Patient's acceptability to dental therapists' role was high and there is potential for development of the role of DCPs with children.</p> <p>Dental care professionals have been shown to provide same quality of service to Dentist</p> <p>In recent cases e.g. dental technicians have been shown to colour match more accurately in an RCT testing use of two different shade guides</p>	<p>(Evans et al., 2007, Galloway et al., 2002)</p> <p>(Dyer and Robinson, 2006b, Dyer and Robinson P.G, 2008, Dyer and Robinson, 2009)</p> <p>(Allred, 1977, Nilchian et al., 2011)</p> <p>(Alomari and Chadwick, 2011)</p>
<b><i>Barriers exist delegation</i></b>	<p>Dentists are not fully delegating.</p> <p>Dentists are unwilling to delegate due to poor understanding of roles and remuneration challenges</p>	(Gallagher and Wright, 2002, Ross et al., 2009, Scottish Government, 2010, Evans et al., 2007, Harris and Burnside, 2004, Sun and Harris, 2011)
<b><i>Team training could improve delegation</i></b>	<p>There is potential in team training for the dental team to develop their understanding of each other's roles</p>	(Ross et al., 2009)
<b><i>Recommendations for improvement of skill mix in dentistry</i></b>	<p>Recommendations to research and model skill mix in public and private care. It is recommended that further research into quality of skill mix and productivity.</p>	(Sun and Harris, 2011, Evans et al., 2007)

#### 10.6.6 Appendix F: SQL data extraction tool-pilot phase extract

```
Select
patients.Sex as Gender, patients.PatientCode, patients.DOB,
Addresses.postcode as Postcode,
EthnicityCategory.[Description] As Ethnicity, Exemptcodes.[Description]
As 'Benefit Status', TreatmentPlans.CreationDate As 'Creation Date',
clinics.Name As Clinic,
TreatmentPlans.CompletionDate as 'Completion Date',
TreatmentPlans.TPNumber As 'Treatment Plan Number',
CarePathway.RecallTimeInMonths As 'Recall Interval', Case Exam.Exist When
1 THEN 'Yes' ELSE 'No' END As Exam,
Case Prescription.Exist When 1 THEN 'Yes' ELSE 'No' END As Prescription,
CarePathwayType.[Description] As 'Risk Status', codes.[Description] from
Patients
    Inner join addresses on patients.AddressId = addresses.AddressId
    Inner join NHSPatientDetails on patients.PatientCode =
NHSPatientDetails.PatientCode
    Inner join EthnicityCategory on NHSPatientDetails.EthnicityCatID =
EthnicityCategory.EthnicityCatID
    Inner join ExemptCodes on patients.ExemptCode =
ExemptCodes.ExemptCode
    Inner Join Clinics on patients.curclinic = clinics.cliniccode
    left outer join CarePathway on patients.PatientCode =
CarePathway.PatientCode
    Inner join (select patientcode, MAX(TPNumber) As TPNumber from
TreatmentPlans GROUP BY Patientcode) As MaxTP ON Patients. PatientCode
=
MaxTP.PatientCode
    Inner join TreatmentPlans ON MaxTP.PatientCode =
TreatmentPlans.PatientCode AND MaxTP.TPNumber = TreatmentPlans.TPNumber
    Inner join (select tpi.PatientCode, tpi.TPNumber, COUNT(TPItem) As
ItemCount FROM TreatmentPlanItems tpi
GROUP BY TPI.Patientcode, tpi.TPNumber) As CountItems
ON TreatmentPlans.PatientCode = CountItems.Patientcode
AND TreatmentPlans.TPNumber = CountItems.TPNumber

    Left outer join (select Patientcode, TPNumber, 1 As Exist from
treatmentplanitems Exams
where Exams.subtypecode=101 GROUP BY Patientcode, TPNumber) As
Exam on treatmentplans.patientcode = Exam.patientcode
and treatmentplans.tpnumber = Exam.tpnumber
    Left outer join (select Patientcode, TPNumber, 1 As Exist from
treatmentplanitems Prescription
where Prescription.subtypecode=9991 GROUP BY Patientcode,
TPNumber) As Prescription on treatmentplans.patientcode =
Prescription.patientcode
and treatmentplans.tpnumber = Exam.tpnumber
    Left Outer Join CarePathwayType on
CarePathway.SetCarePathwayTypeID = CarePathwayType.SystemID
    Inner Join Transactions on patients.PatientCode =
transactions.PatientCode
    Inner Join Codes on Transactions.CodeID = codes.CodeID

where Treatmentplans.CreationDate between '2008-08-01 00:00:00.000' and
'2012-08-31 12:59:59.000'
and Transactions.CodeID IS NOT NULL and (Transactions.SubTypeCode IS NOT
NULL AND Transactions.SubTypeCode <> 8)
And Transactions.Deleted = 0
```

### 10.6.7 Appendix G: Data request modification for phase 2 data extract

Below are two tables A and B. A was used to appraise the pilot extract indicating areas where there would need to modifications to obtain a better second extract. B was used to inform additional variables requested for the second main extract, which were deemed useful in the subsequent main data analysis

#### A] Initial set of variables from Pilot extract

Variable	Comment
Sex	This was fine- we were able to obtain all observations
Patient ID no	This was fine – we were able to obtain all fields
Post code	This was also well picked up- There were several missing observations, but I assume these were not on the picked up by people who build up the patient file
Ethnicity	This was fine
Payment status/ exemption status	Also well represented
Treatment plan creation date	This was well represented
Clinic	This was not well picked up. It seems it took the overall clinic name and most cases were assigned to the William Beatty clinic-  If we picked up LOCATION- as well which is available from the NHS CLAIMS section of the system we would have the student clinics which patients were seen
Treatment plan end date	This was not well shown, there were times but no dates ( we tried to format cells in excel but it still showed minutes and seconds only) could we try again to modify this field
Treatment plan number	This did not change within the treatments - can we try to pick this up from the NHS claim tables
Recall interval	There were a lot of blank fields, I wonder if this interval is picked up only on the closed plan- however we would still like this to be picked up again
Exam	This was fine
Prescription to DCP	This was fine
RAG ( risk rating)	There were a lot of NULL fields- perhaps we will get more representation in the next set
Treatment ( description)	This was well represented

**Below is [B]: Additional variables for amendment of script.** In order to complement some of the above variable, we would like a few more variables added to the script. Below is a list with comments and locations of the variables on the system.

[B]

Variable	Comment
NHS Activity category	This is another description of treatments, we feel that if we had description code and NHS activity group we would have useful information
Treatment accepted or completed ( please note this is the individual treatments and note the treatment plan as a whole)	Adjacent to treatments there is an A or C which indicates whether the treatment is complete or note this would be a useful variable to have as well
NHS Charge band	This is visible on the NHS Claim section. It will give information of which band the treatments were assigned
Location	This is in the NHS claim section, it gives the student clinic where treatment took place
Smoking status	This is in the NHS claim tab- within the PDS plus contract- there is a question on the smoking status.

We hoped to also get: but were told it was not possible. If it is simple to do please include, **Dental treatment claim options:** Urgent- **yes or no** :**New Patient- yes or no**



## 10.6.8 Appendix H: Data script phase 2

```
-- Script to produce the report on Portsmouth Dental Academy Activity for the
-- period between 01/08/2008 and 31/08/2012.
Select distinct
patients.Sex as Sex,
patients.PatientCode,
convert(varchar(10),patients.DOB,103) as 'Patient DOB',
Addresses.postcode as Postcode,
EthnicityCategory.[Description] As Ethnicity,
Exemptcodes.[Description] As 'Benefit Status',
convert(varchar(10),TreatmentPlans.CreationDate, 103) As 'Creation Date',
convert(varchar(10),[2006claimssubmission].TreatmentStartDate, 103) as 'TreatmentStartDate',
convert(varchar(10),[2006claimssubmission].CompletionDate, 103) as '
TreatmentCompletionDate',
clinics.Name As Clinic,
convert(varchar(10), TreatmentPlans.CompletionDate, 103) as 'Completion Date',
TreatmentPlans.TPNumber As 'Treatment Plan Number',
CarePathway.RecallTimeInMonths As 'Recall Interval',
CarePathwayType.[Description] As 'Risk Status',
codes.[Description] ,
Clinics.LocationNumber as clinicLocation,
Clinics.[Name] as 'ClinicName',
codes.NHSCatID as NHSCategory,
NHSCategories.Title as 'NHSTitle',
NHSCategories.CategoryDescription as 'NHSCategoryDescription',
NHSChargeBands.NHSChargeBandID as NHSChargeBand,
NHSChargeBands.BandDescription as 'NHSBandDescription',
--ChargeValues.ChargeValueSetID,
NHSPDSPlusValues.UrgentAppointment,
NHSPDSPlusValues.Newpatient,
NHSPDSPlusValues.HealthPromotionSmokingStatus,
NHSPDSPlusValues.HealthPromotionSmokingCessation,
NHSPDSPlusValues.FlourideVarnish,
NHSPDSPlusValues.DentalCareAssesment as 'Offer accepted or Not',
NHSPDSPlusValues.ToothDecayAssesment as 'Number of decayed teath',
NHSPDSPlusValues.BasicPeriodontalExam as 'BPE',
NHSPDSPlusValues.VisiblePlaque,
NHSPDSPlusValues.AntibioticItemsPrescribed,
Codes.Description
from Patients
    Inner join addresses on patients.AddressId = addresses.AddressId
    Inner join NHSPatientDetails on patients.PatientCode = NHSPatientDetails.PatientCode
    Inner join EthnicityCategory on NHSPatientDetails.EthnicityCatID =
EthnicityCategory.EthnicityCatID
    inner join ExemptCodes on patients.ExemptCode = ExemptCodes.ExemptCode
    inner Join Clinics on patients.curclinic = clinics.cliniccode
    left outer join CarePathway on patients.PatientCode = CarePathway.PatientCode
    inner join (select patientcode, MAX(TPNumber) As TPNumber from TreatmentPlans
GROUP BY Patientcode) As MaxTP ON Patients.PatientCode = MaxTP.PatientCode
    inner join TreatmentPlans ON MaxTP.PatientCode = TreatmentPlans.PatientCode AND
MaxTP.TPNumber = TreatmentPlans.TPNumber
    inner join (select tpi.PatientCode, tpi.TPNumber, COUNT(TPIItem) As ItemCount FROM
TreatmentPlanItems tpi
GROUP BY TPI.Patientcode, tpi.TPNumber) As CountItems ON
TreatmentPlans.PatientCode = CountItems.Patientcode
AND TreatmentPlans.TPNumber = CountItems.TPNumber
    left outer join ( select patientcode, TPNumber, 1 as Exist from TreatmentPlanItems Exams
where Exams.SubTypeCode = 101 GROUP by PatientCode, TPNumber) As
Exam ON TreatmentPlans.PatientCode = Exam.PatientCode And TreatmentPlans.TPNumber =
Exam.TPNumber
```



```

left outer join ( select patientcode, TPNumber, 1 as Exist from TreatmentPlanItems
Prescription
                where Prescription.SubTypeCode = 9991 GROUP by PatientCode, TPNumber)
As Prescription ON TreatmentPlans.PatientCode = Prescription.PatientCode And
TreatmentPlans.TPNumber = Prescription.TPNumber
Left Outer Join CarePathwayType on CarePathway.SetCarePathwayTypeID =
CarePathwayType.SystemID
Inner Join Transactions on patients.PatientCode = transactions.PatientCode
Inner Join Codes on Transactions.CodeID = codes.CodeID
inner join NHSCategories on NHSCategories.NHSCategoryID = codes.NHSCatID
inner join NHSCategoryBands on NHSCategoryBands.NHSCategoryID =
NHSCategories.NHSCategoryID
inner join NHSChargeBandValues on NHSChargeBandValues.NHSChargeBandID =
NHSCategoryBands.NHSChargeBandID
left outer join (select b.NHSCategoryID CategoryID, b.NHSChargeBandID as
ChargeBandID, c.StartDate as s_Date,
                max(c.StartDate) as Date_Started
from NHSCategoryBands b
inner join dbo.NHSCategoryDates c on b.NHSCategoryDateID = c.NHSCategoryDateID
where c.StartDate between '2008-08-01 00:00:00.000' and '2012-08-31 12:59:59.000'
GROUP BY b.NHSCategoryID, b.NHSChargeBandID, c.StartDate) Bands on
Bands.CategoryID = NHSCategories.NHSCategoryID
left outer join NHSChargeBands on NHSChargeBands.NHSChargeBandID =
Bands.ChargeBandID
inner join [2006Claim] on [2006Claim].PatientCode = Patients.PatientCode and
DateAccepted between '2008-08-01 00:00:00.000' and '2012-08-31 12:59:59.000'
inner join [2006ClaimMessage] ON [2006ClaimMessage].[2006ClaimID] =
[2006Claim].[2006ClaimID]
inner join [2006claimsubmission] ON [2006claimsubmission].[2006ClaimMessageID] =
[2006ClaimMessage].[2006ClaimMessageID]
inner join (
SELECT
[2006Claim].[2006ClaimID],MAX([2006claimsubmission].SubmissionNum) AS LastSettled
FROM [2006Claim]
INNER JOIN [2006ClaimMessage] ON [2006ClaimMessage].[2006ClaimID] =
[2006Claim].[2006ClaimID]
INNER JOIN [2006claimsubmission] ON
[2006claimsubmission].[2006ClaimMessageID] = [2006ClaimMessage].[2006ClaimMessageID]
WHERE [2006claimsubmission].SendStatus in (5,6) and TreatmentStartDate
between '2008-08-01 00:00:00.000' and '2012-08-31 12:59:59.000'
GROUP BY [2006Claim].[2006ClaimID]
) MSettlement ON MSettlement.[2006ClaimID] = [2006Claim].[2006ClaimID] AND
MSettlement.LastSettled = [2006claimsubmission].SubmissionNum
left outer join NHSPDSPlusValues ON NHSPDSPlusValues.ClaimSubmissionID =
[2006claimsubmission].[2006ClaimSubmissionID] and [2006claimsubmission].SendStatus
in(5,6)
Where Treatmentplans.CreationDate between '2008-08-01 00:00:00.000' and '2012-08-31
12:59:59.000'
and Transactions.CodeID IS NOT NULL and (Transactions.SubTypeCode IS NOT NULL
AND Transactions.SubTypeCode <> 8)
And Transactions.Deleted = 0
--and patients.PatientCode = 1011714 For testing only
--and patients.PatientCode = 1011592
--and Codes.[Description] like 'Ama%'
--order by patients.PatientCode, [2006claimsubmission].TreatmentStartDate

```

### 10.6.9 Appendix I Variables appraisal and selection criteria

Listed below are the variables which were included in the data set. Some were used in analysis while some were not. For each of the variables named, a description of the nature of the variable and whether it was not used is discussed or whether it was used to derive other variable or data sets is revealed. For all demographic variable only descriptions are mentioned as all these were used in analysis. All variables which are 'overridden' have been marked with a bold '**O**' (Overridden means that when these variables are updated the previous score or information is lost)

First described is variables found in both the pilot and the main extract. Following which descriptions of variable obtained only in the second (main extract are described), re-coded variables and finally derived variables.

#### A. Variables in both pilot and main extract

1. Sex: This is presented as Male or female
2. Patient id : Patient identification number
3. DOB: Date of birth
4. Postcode: This is the patient's post-code converted to other geographic variables
5. Ethnicity: Ethnicity with 17 domains
6. Exemption status: Whether patient was on benefits/under 18 years or exempt from payment.
7. Creation date [**O**]: This indicates the date of creation of a new treatment plan. It however it represents only the most recent treatment plan date whether a plan is completed or not.
  - If we assigned patients to years of treatment based on this date, there would only be one occurrence of a patient within the data set (i.e. if a patient was seen previously we would not pick them up).
  - If the plan is incomplete the creation date indicates when the last plan was opened, but does not have corresponding treatment activities for an incomplete plan ( this applies to phase 2 data only, because we did not restrict to maximum treatment plan only as we did in the pilot extract
8. Treatment start date:
  - Indicates the date of start for each treatment plan and largely coincides with treatment complete date
9. Plan complete date [**O**]:
  - This indicates the date of the end of the last treatment plan. If the plan is not complete, this remains blank
10. Treatment complete date
  - This indicates the date of each treatment plan ended.
11. Clinic
  - These were clinics where the patients were treated as marked in the PATIENT MANAGEMENT SYSTEM. The preliminary descriptive analysis showed that this variable was not useful in our analysis due to inconsistencies: see below the distribution of treatments by clinics.

Clinic	Frequency	Per cent
2nd Year Student Clinic (level 5)	298	.1
3rd Year Student Clinic ( level 6)	590	.1
DS Hamble	4346	.9
DS Langstone	4208	.9
DS Meon	1266	.3
DS Solent	4156	.9
Staff clinic	389416	84.6
William Beatty dental service	56004	12.2
Total	460284	100.0

As visible the majority of treatments had not been accurately assigned to a clinic where they were actually seen due to the inconsistent to updating of this variable post-expansion. A

disproportionate number of cases were seen in the closed WBDS. Also of concern was that some treatment plans where treatments were done in 2009 were registered in DS clinics, which were not in existence at the time. This suggests that the variable is may have been overridden at times and inconsistently updated. We opted not to use this variable

12. Treatment plan number [O]:

This variable indicates that there are 23 different possible plans to belong to. In the pilot we had poor reporting of this majority of the cases pulled of the system were null.

In the second extraction there were no missing values, however, this corresponds to the maximum (most recent) treatment plan created. In the last data set it may have not picked up because we restricted the plans to completed ones only. We opted not to use this variable

13. Recall interval : this is the recall interval set on the last completed plan in the last set this was poorly reported as shown below

Recall interval	Frequency	Per cent
0	92463	20.1
1	1410	.3
12	7809	1.7
18	376	.1
3	32011	7.0
6	29350	6.4
9	1393	.3
Null	295472	64.2
Total	460284	100.0

14. Risk status[O]: there was poor reported in both the main and the pilot extract: below is a description

Risk status	Frequency	Per cent
Amber	29656	6.4
Green	102403	22.2
Null	295472	64.2
Red	32753	7.1
Total	460284	100.0

Please note that the same numbers of null fields are present with the recall interval  
We opted not to use this variable

15. Description:

This is the pick variable for the data-set, it describes each treatment items received by the patient it is the variable which was to have no duplication. In the pilot data, there were not repetitions. In the main data set, this variable showed a systematic error of repetition, this led us to modify the use of the variable, by working with proportions when we required an estimate of volume of activity. It was possible to use this variable also to create other data sets to investigate particular treatments.

16. Clinic location:

Provides a code- there are only two codes 10475 representing 0.2% of the treatment items 11113 holds 99.8% of the treatments. We opted not to use this variable

17. Clinic name: Same as clinic

18. NHS category: This is a numerical variable- from 1-107 treatments could fall under any of the 107- we are unable to ascertain what they represent

19. NHS title: This is a highest level (grouping variable for the treatment items (description or NHS band description which are the same and describe a definite treatment item) there are 69 different types of NHS titles. We used this variable to describe treatment groups within our analysis

20. NHS category description: This describes NHS title for example if NHS title indicated tooth restoration this variable would indicated that the tooth restoration could be, GIC, amalgam, silicone etc.. 72 different descriptions are available

21. NHSs charge band: This variable was not reported accurately. It only identified urgent/band, 1 or urgent and band 1 leaving out 2 and 3. This resultant output was not clear. We opted not to use this variable in our analysis

22. NHS band description- Further describes NHS charge band. We opted not to use this variable in our analysis

B. Variables in the main extract only (post-expansion only variables)

The following 9 variables were introduced after expansion into UPDA as part of the PDS plus contract. The records of these are only present in treatment plans conducted in the two years after expansion

1. Urgent appointment
2. New Patient
3. Smoking Status
4. Smoking cessation
5. Fluoride Varnish
6. Dental care assessment
7. Number of decayed teeth
8. BPE
9. Visible plaque

All these 9 variables were overridden on new treatment plans [O]. They were therefore not very useful in trend analysis, however, the variable on smoking cessation sign posting was useful in indicating the number of smokers in the system. As policy, once one is identified as a smoker they remain so on the system and are signposted. It was therefore possible to extrapolate that this was an indicator of smokers and a variable created for patients who had been signposted, was created as a proxy to smoking status.

C. Re-coded variables

These were variables which were computed using variables extracted from the data set. For example from date of birth age was coded. The following is a list of all re-codes

1. Age
2. Sex
3. Ethnicity recoded
4. Exemption recode
5. Monthly plan completion
6. Academicyr2
7. Quintiles of deprivation
- D. Derived variables

The following variables were used in the geographical mapping and multilevel modelling; they have been obtained from converting Postcodes to excel files of the most recent geographical deprivation data and matching these with postcodes. IMD 2010 is in use in this data as it is now available.

Code	Description
1. Lsoacode	Lower super output area code
2. Wardcode	Ward code
3. Wardname	Ward name
4. Rankofimdscorewhere1ismostdepriv	Rank of Indices of multiple deprivation score(IMD)
5. Imdscore	IMD score (IMD)
6. Incomescore	Income deprivation score
7. Rankofincomescorewhere1ismostdep	Rank of income deprivation score
8. Employmentscore	Employment deprivation score
9. Rankofemploymentscorewhere1ismos	Rank of employment deprivation score
10. Healthdeprivationanddisabilitysc	Health deprivation and disability score
11. Rankofhealthdeprivationanddisabi	Rank of health deprivation and disability score
12. Educationskillsandtrainingscore	Education, skills and training deprivation score
13. Rankofeducationskillsandtraining	Rank of Education, skills and training deprivation score
14. Barrierstohousingandservicesscor	Barriers to housing and services score
15. Rankofbarrierstohousingandservic	Rank of Barriers to housing and services score
16. Crimeanddisorderscore	Crime and disorder score
17. Rankofcrimescorewhere1ismostdepr	Rank of crimes score
18. Livingenvironmentscore	Living and environment deprivation score
19. Rankoflivingenvironmentscorewher	Rank of Living and environment deprivation score

20. Indoorssubdomainscore	Indoor deprivation sub-domain score
21. Indoorssubdomainrankwhere1ismost	Rank of Indoor deprivation sub-domain score
22. Outdoorssubdomainscore	Outdoor deprivation sub-domain score
23. Outdoorssubdomainrankwhere1ismos	Rank of outdoor deprivation sub-domain score
24.	
25. Geographicalbarrierssubdomainsco	Geographical barriers to services sub-domain
26. Geographicalbarrierssubdomainran	Rank of Geographical barriers to services sub-domain
27. Widerbarrierssubdomainscore	Wider barriers to services sub-domain score
28. Widerbarrierssubdomainrankwhere1	Rank of Wider barriers to services sub-domain score
29. Childrenyoungpeoplesubdomainscor	Children, young people deprivation sub-domain score
30. Childrenyoungpeoplesubdomainrank	Rank of Children, young people deprivation sub-domain score
31. Skillssubdomainscore	Skills deprivation sub-domain score
32. Skillssubdomainrankwhere1ismostd	Rank of Skills deprivation sub-domain score
33. Idaciscore	
Rankofidaciwhere1ismostdeprived	
34. Idaopiscore	
Rankofidaopiwhere1ismostdeprived	
35. Quintileofdepin PCT	Quintile of deprivation within the Primary care trust

  
**Business Services Authority**

Our Ref: 3845

Ms Kristina Wanyonyi

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Date: 8 November 2013

Dear Ms Wanyonyi,

**Subject: FREEDOM OF INFORMATION REQUEST**

I am writing to confirm that I have now completed my search for the information which you requested on 21 October 2013, as outlined below:

*'To whom it may concern We would like request data from the NHS Business Service Authority. The request is detailed in the attached document. The data will be used for educational purposes in a King's College London Doctoral study, which seeks to model the future dental workforce demands based on observed treatment activities and patient populations seen in the NHS. In summary the request includes:*

- 1. The total number of patients seen by patient type ( age bands and NHS payment status) , for England and each region (either the 11 strategic health authorities or the four new regional teams for the year 2011/12) See table 1 in attachment*
- 2. The estimated total number of clinical items by patients type (age bands and NHS payment status) for England and each region (either the 11 strategic health authorities or the four new regional teams for the year 2011/12) See table 2 in attachment*
- 3. The estimated total number of Courses of Treatment that contain each clinical treatment by patients type (age bands and NHS payment status) for England and each region (either the 11 strategic health authorities or the four new regional teams for the year 2011/12) See table 3 in attachment*

*We look forward to your response. Best wishes'*

A copy of the information is attached. The Excel spreadsheet is read only. Please click on the "Read only" button to access the information.

Total number of patients is split by general and orthodontic treatment. If a patient has both in the time period they will be counted more than once.

The total numbers of patients seen by age range will differ from the total by charge status. Those who change age groups during the period are counted more than once.

All counts are extracted from the year end activity reports for England and excludes Vocational Dental Practitioner (VDP) activity.

## Data Sources

### 1. Form FP17

Dentists are required to submit a form called an FP17 for every course of NHS dental treatment they provide. The FP17 form can be submitted either on paper or electronically. The information contained on the FP17 form is either scanned (if a paper submission) and imported or imported directly (if an electronic submission) and stored electronically in the NHS Dental Services data repository (NHS Dental Services Data Warehouse).

### 2. NHS Dental Services Payments on line (POL)

This holds information created and maintained by NHS commissioners to administer and monitor dental contracts to enable payments to dentists.

### 3. NHS Dental Services Data Warehouse

The information we collect from dental activity forms (FP17s) is combined with the information taken from our online payment system.

Terms used are defined in the notes attached.

Please note that this information will be published on our Freedom of Information disclosure log at:

[https://www.ppa.org.uk/NHSBSA\\_foiRequest/foiRequestDetail.do?bo\\_id=3845](https://www.ppa.org.uk/NHSBSA_foiRequest/foiRequestDetail.do?bo_id=3845)

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If you are unhappy with the service you have received in relation to your request and wish to make a complaint or request a review of my decision, you should write to:

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Goldcrest Way  
Newburn Riverside Business Park  
Newcastle upon Tyne  
NE15 8NY



Details of how we will handle your review request are available on our website at:

<http://www.nhsbsa.nhs.uk/Documents/NHSBSACorporatePoliciesandProcedures/DPre-usePSIEIRandFOIInternalReview.pdf>

If you are not content with the outcome of your complaint, you may apply directly to the Information Commissioner's Office (ICO) for a decision. Generally, the ICO cannot make a decision unless you have exhausted the complaints procedure provided by the Authority.

The Information Commissioner can be contacted at:-

Information Commissioner's Office  
Wycliffe House  
Water Lane  
Wilmslow  
Cheshire  
SK9 5AF

Tel: 01625 545 745

Fax: 01625 524 510

Email: [enquiries@ico.gsi.gov.uk](mailto:enquiries@ico.gsi.gov.uk)

If you have any queries about this letter, please contact me. Please quote the reference number above in any future communications to make it easier for me to deal with your correspondence.

Yours sincerely



Chris Gooday  
Information Governance Manager

cc Gordon Wanless, Head of Information Governance

## 10.6.11 Appendix K: Ethics approval from NHS REC

### NRES Committee London - Fulham

Charing Cross Hospital  
Room 4W/12, 4th Floor  
Charing Cross Hospital  
Fulham Palace Road  
London W6 8RF  
Telephone: 020 3311 7227  
Facsimile: 020 3311 7280

Ms Kristina Lutomya Wanyonyi  
PhD student  
King's College London Dental Institute  
Denmark Hill Campus,  
Caldecot Road  
SE5 9RW

25 July 2011

Dear Ms Wanyonyi

<b>Study title:</b>	<b>Dental workforce planning: modelling the dental workforce skill-mix in a primary care dental training institution</b>
<b>REC reference:</b>	<b>11/LO/1138</b>
<b>Protocol number:</b>	<b>NTMHWM0V3</b>

The Proportionate Review Sub-committee of the NRES Committee London - Fulham Research Ethics Committee reviewed the above application on 18 July 2011.

#### **Ethical opinion**

The sub-committee noted that the application is not in lay language.

On behalf of the Committee, the sub-committee gave a favourable ethical opinion of the above research on the basis described in the application form, protocol and supporting documentation, subject to the conditions specified below.

#### **Ethical review of research sites**

The favourable opinion applies to all NHS sites taking part in the study, subject to management permission being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion" below).

#### **Conditions of the favourable opinion**

The favourable opinion is subject to the following conditions being met prior to the start of the study.

Management permission or approval must be obtained from each host organisation prior to the start of the study at the site concerned.

*Management permission ("R&D approval") should be sought from all NHS organisations involved in the study in accordance with NHS research governance arrangements.*

*Guidance on applying for NHS permission for research is available in the Integrated Research Application System or at <http://www.rdforum.nhs.uk>.*

## 10.6.12 Appendix L: R& D approval from HIOW shared RM & G service



Ref: PS  
Wednesday 12<sup>th</sup> October 2011

Ms Kristina Wanyonyi  
King's College London Dental Institute  
Denmark Hill Campus  
Caldecot Road  
London  
SE5 9RW

**HIOW Shared RM&G Service**  
2nd Floor Adelaide Health Centre  
Western Community Hospital Campus  
William Macleod Way  
Southampton  
SO16 4XE  
T: 023 8060 8925  
E: [sharedrmandg@scpct.nhs.uk](mailto:sharedrmandg@scpct.nhs.uk)

Dear M Wanyonyi

**RM&G Reference Number: SSPS/057/11**  
**Study title: Dental Workforce Skill-mix Study: Modelling the Workforce Skill-mix**

In accordance with the Department of Health's Research Governance Framework for Health and Social Care, all research projects taking place within the Trust must receive a favourable opinion from an ethics committee and permission from the Department of Research and Development (R&D) prior to commencement.

On behalf of Portsmouth City PCT, the Shared RM&G Service reviewed the documentation submitted for the above research study and I am pleased to confirm NHS permission. The Patient Identification Centre (PIC) where you are permitted to undertake the research is listed in the attached appendix. The addition of a new site(s) must be notified to the Shared RM&G Service by submitting an SSI form and for PICs, a revised R&D Form.

I would like to bring your attention to the attached list of conditions of approval and specifically to the mandatory requirement to record the recruitment for all sites within this Trust onto the E-dge database. Your study will be subject to monitoring and you will be required to comply with the requests in addition to the submission of annual reports.

### Documents Reviewed

Document	Version	Date
NHS R&D Form	3.1	
Protocol	14	29/06/2011
Advertisement	1	29/06/2011
Letter from KLC		28/06/2011
Letter from University of Portsmouth		27/06/2011
Participant Information Sheet	1	29/07/2011

I wish you every success with your study and look forward to hearing from you.

Yours sincerely

**Miss Penny Silsbury**  
**Research Governance Officer**  
Hampshire & IOW Shared RM&G Service

## 10.6.13 Appendix M: Information poster for all patients and extra information sheet

### Dental Skill Mix study: University of Portsmouth Dental Academy Information for all patients



#### Did you know?

The University of Portsmouth Dental Academy is a unique learning institution which runs on a new team based learning model to improve the training of Dental professionals.

#### What is the Dental Skill Mix study?

A PhD student will be conducting a study that looks at the treatment activities in the Dental Academy before and after the new training model. This study will evaluate the processes and provide useful contributions to knowledge on training and work patterns of Dental professionals. The study is also being undertaken as for educational purposes as part of the student's degree.

#### What information will be studied?

The Dental Academy's treatment records will be analysed by the researchers in the University of Portsmouth and Kings College London. A thesis, reports and publications on the findings only will be produced.

#### Will patients be identified in the information used?

No, The information used will be of the treatment activities and general social data, all of which cannot be traced to individuals. The researchers will not be able to identify the patients as names and address will not be used.

#### What should I do if I want further information?

If you wish to have your data excluded or want more information, please contact the receptionist.

**KING'S**  
*College*  
**LONDON**

  
University of  
**Portsmouth**

Version 1.0 29/06/2011

#### 10.6.14 Appendix N: Dental skill mix study: UPDA: participant extra-information sheet

Study Title: Dental skill mix study: modelling dental workforce skill-mix in a primary care dental training institution

Researcher/chief investigator:

Kristina L Wanyonyi -Mphil/PhD student

Email address: kristina.wanyonyi @kcl.ac.uk

Your anonymised patient information is to be used to investigate the processes of care within the University of Portsmouth. As we are unable to identify individuals, all patient treatment and non-identifiable social data will be included, unless you opt to have your data excluded. If you decide it is important for you to understand why the research is being done, and what is involved. **Please take time to read the following information carefully.**

What is the purpose of the study?

This purpose of this study is to evaluate the care processes provided by students and provide useful contributions to knowledge on training and work patterns of student dental professionals which will inform future dental workforce training and planning. The study is also being undertaken for educational purposes as part of my degree.

What does the study involve?

The study involves quantitative analysis of treatment activities and patient proportions. Patterns of treatment and patient attendance will be investigated and used to test, ideal working scenarios within the dental team. The data will also be compared to local and national findings, in order to contribute to the workforce planning locally and nationally.

Please contact me to discuss any questions you may have, if anything is not clear or if you would like any additional information. Take time to decide whether or not you wish to take part.

Is the data confidential?

The data to be used will not identify individual patients, the data will be anonymized as, names and addresses will not be used. If you still wish to have your information excluded, please inform the receptionist and we will facilitate this process.

Who reviewed the study?

This study has been reviewed by London Fulham NHS Research Ethics Proportionate Review Sub-Committee

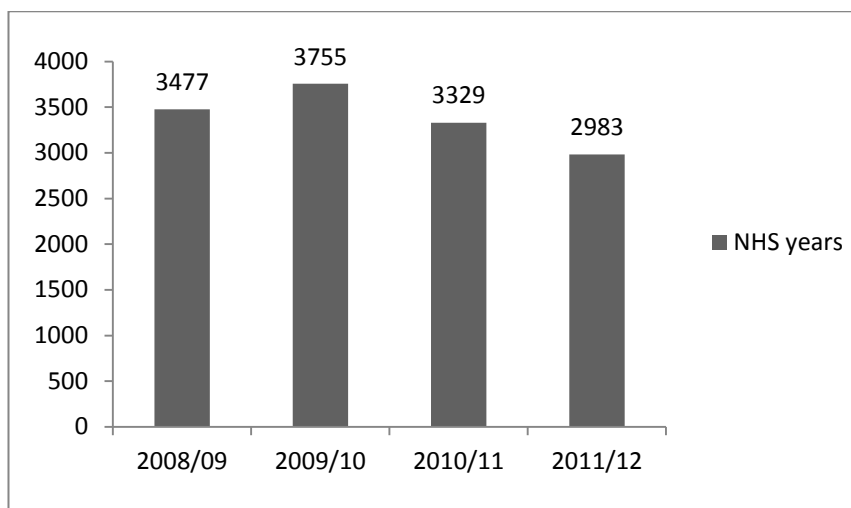


### 10.6.15 Appendix O: Proportion of treatments in the last two academic years of skill mix

Treatment type	Treatment description	year 1	year 2	As a proportion of all treatment in both years	Numeric Coding variable
1. Assessment and diagnosis	Case Assessment	3.8%	4.1%	3.9%	0.0
	Colour Photographs Exam	1.9%	1.7%	1.8%	0.0
	/Assessment Radiograph: Panor	57.9%	60.3%	58.9%	0.0
	oral	.7%	.6%	.6%	0.0
	Radiographs Intra Oral	2.2%	2.2%	2.2%	0.0
	Study Casts	.1%	.1%	.1%	0.0
		66.5%	69.0%		
2. Prevention	Fissure Seal Preventative	.4%	.4%	.4%	1.0
	Instruction / Advice	8.9%	10.0%	9.4%	1.0
	Perio: Flap / Curettage of root / Bone	.0%		.0%	1.0
	Scale / Polish	2.2%	2.1%	2.2%	1.0
	Sealant restorations	.7%	.5%	.6%	1.0
	Topical Fluoride Preventative	3.7%	3.7%	3.7%	1.0
	Advice	.1%	.1%	.1%	1.0
3. Basic treatments		16.0%	17.0%		
	Band 1 Treatment	.0%	.0%	.0%	2.0
	Band 1 Urgent Treatment	.0%	.0%	.0%	2.0
	Band 2 or Urgent	.0%	.0%	.0%	2.0
	Band 2 Treatment	.0%	.0%	.0%	2.0
	Dressings	.3%	.3%	.3%	2.0
	Tooth restoration	4.6%	4.3%	4.5%	2.0
4. Complex restorative	Perio: Non-Surgical	2.6%	2.3%	2.5%	2.0
		7.6%	6.9%		
	Apicectomy	.0%	.0%	.0%	3.0
	Endodontics	.3%	.3%	.3%	3.0
	Pulpotomy	.1%	.1%	.1%	3.0
		.4%	.3%		
5. Miscellaneous	Antibiotic Prescription	.1%	.1%	.1%	6.0
	Other Free Item	6.8%	4.1%	5.7%	6.0
	Pathological exam	.0%	.0%	.0%	6.0
	Prescription	.0%	.0%	.0%	6.0
	Remove Sutures	.0%	.0%	.0%	6.0
	Treat Sensitivity	.0%	.1%	.0%	6.0
	Urgent Treatment for Acute Conditions	.1%	.2%	.1%	6.0

Cont: Treatment type	Treatment description	year 1	year 2	As a proportion of all treatment in both years	Numeric Coding variable
6. Prosthetic	Band 3 Treatment	.1%	.1%	.1%	4.0
	Bridge Acid Etch	.1%	.1%	.1%	4.0
	Bridge Alloy	.1%	.1%	.1%	4.0
	Bridge Gold	.0%	.0%	.0%	4.0
	Bridge Other Materials	.0%	.0%	.0%	4.0
	Bridge Refix	.0%	.1%	.0%	4.0
	Bridge Repair	.0%	.0%	.0%	4.0
	Bridge Temporary	.0%		.0%	4.0
	Crown Alloy	.0%	.0%	.0%	4.0
	Crown Other Materials	.0%	.0%	.0%	4.0
	Crown PM	.0%	.0%	.0%	4.0
	Crown Porc / Resin	.0%	.0%	.0%	4.0
	Crown Porc Bonded	.2%	.1%	.1%	4.0
	Crown Prefab	.0%	.0%	.0%	4.0
	Crown Repair / Refix	.1%	.1%	.1%	4.0
	Denture	.0%	.0%	.0%	4.0
	Denture Addition	.1%	.1%	.1%	4.0
	Denture Adjust	.0%	.0%	.0%	4.0
	Denture Full Lower Acrylic	.0%	.0%	.0%	4.0
	Denture Full Lower Metal	.0%		.0%	4.0
	Denture Full Upper Acrylic	.0%	.0%	.0%	4.0
	Denture Full Upper Metal	.0%		.0%	4.0
	Denture Partial Acrylic	.2%	.2%	.2%	4.0
	Denture Partial Metal	.1%	.1%	.1%	4.0
	Denture Reline / Rebase	.0%	.0%	.0%	4.0
	Denture Repair	.0%	.0%	.0%	4.0
	Inlay Repair / Refix	.0%	.0%	.0%	4.0
	Inlays	.0%	.0%	.0%	4.0
	Other Appliance	.0%		.0%	4.0
	Splints	.0%	.0%	.0%	4.0
	Veneer	.0%	.0%	.0%	4.0
		1.4%	1.2%		
7. Surgical	Arrest Bleeding	.0%		.0%	5.0
	Extractions(Non-surgical)	.9%	.9%	.9%	5.0
	Incising an Abscess	.0%	.0%	.0%	5.0
	Perio: Gingival / Operculum	.0%	.0%	.0%	5.0
	Post-Op Care	.0%	.0%	.0%	5.0
	Surgery: Oral	.0%		.0%	5.0
	Surgical Extractions	.1%	.1%	.1%	5.0

#### 10.6.16 Appendix P Patient volumes by NHS years (BSA reports)



\*NHS patients are counted as many times as they appear in the NHS year regardless of if treatment plans were completed, this would increase their numbers compared to the research data set which limits patients to those with complete plans

Source: NHS Business Authority



### 10.6.17 Appendix Q Skill mix at UPDA-detailed analysis of clinical items delegated

Clinical item	number of items	proportion
Amalgam Filling - 1 surface DS	297	2
Amalgam Filling - 1 surface HTS	170	1.1
Amalgam Filling - 2 surfaces DS	549	3.7
Amalgam Filling - 2 surfaces HTS	299	2
Amalgam Filling - 3 surfaces DS	219	1.5
Amalgam Filling - 3 surfaces HTS	58	0.4
Amalgam Filling - 4+ surfaces DS	76	0.5
Amalgam Filling - 4+ surfaces HTS	6	0
Composite Filling - 1 surface DS	1165	7.8
Composite Filling - 1 surface HTS	1678	11.2
Composite Filling - 2 surfaces DS	951	6.3
Composite Filling - 2 surfaces HTS	825	5.5
Composite Filling - 3 surfaces DS	427	2.8
Composite Filling - 3 surfaces HTS	175	1.2
Composite Filling - 4+ surfaces DS	200	1.3
Composite Filling - 4+ surfaces HTS	32	0.2
Crown - Temporary Recement HTS	18	0.1
Extraction - Simple DS	6	0
Extraction DS	1689	11.3
Extraction HTS	41	0.3
Fissure Sealant with Composite HTS	71	0.5
Fissure Sealant with Glass Ion. & Comp HTS	2	0
Fissure Sealant/Enamel Biopsy DS	150	1
Fissure Sealant/Enamel Biopsy HTS	666	4.4
Fissure Sealant/Preventative DS	150	1
Fissure Sealant/Preventative HTS	1240	8.3
Glass Ionomer - 1 surface DS	427	2.8
Glass Ionomer - 1 surface HTS	670	4.5
Glass Ionomer - 2 surfaces DS	188	1.3
Glass Ionomer - 2 surfaces HTS	346	2.3
Glass Ionomer - 3 surfaces DS	78	0.5
Glass Ionomer - 3 surfaces HTS	32	0.2
Glass Ionomer - 4+ surfaces DS	55	0.4
Glass Ionomer - 4+ surfaces HTS	12	0.1
Glass ionomer-2 surface HTS	6	0
Provisional Restoration (Step Wise) DS	136	0.9
Provisional Restoration (Step Wise) HTS	121	0.8
Pulpotomy (Deciduous) HTS	55	0.4
Pulpotomy DS	75	0.5
Stainless Steel Crown (Deciduous) HTS	23	0.2
Stoning & Smoothing Tooth DS	382	2.5
Stoning & Smoothing Tooth HTS	171	1.1
Temporary Dressing DS	637	4.2
Temporary Dressing HTS	224	1.5
Urgent Trt - Acute Mucosal Conditions DS	198	1.3
Total	14996	100

**10.6.18 Appendix R Expressed demand for dental treatment in England 2011/12 FP17s**

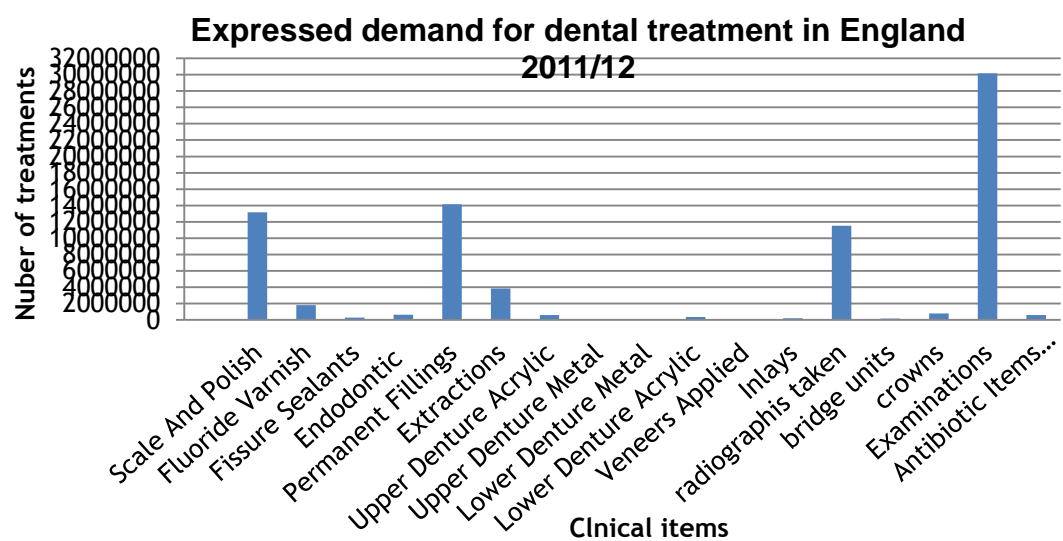
**that contain nical treatment items listed**

Patent Age Range	FP17s with Scale And Polish	FP17s with Fluoride Varnish	FP17s with Fissure Sealants	FP17s with Endodontic Treatment	FP17s with Permanent Fillings	FP17s with Extractions	FP17s with Upper Denture Acrylic	FP17s with Upper Denture Metal	FP17s with Lower Denture Metal	FP17s with Lower Denture Acrylic	FP17s with Veneers Applied	FP17s with Inlays	FP17s with Bridges Fitted	FP17s with Examination	FP17s with Antibiotic Items Prescribed
0 - 2	5,358	20,818	387	27	5,990	1,398	41	0	0	16	4	10	2	624,671	1,132
03 - 05	29,163	229,920	3,036	849	226,115	33,255	132	2	0	17	5	15	2	1,570,807	11,312
06 - 12	310,623	778,665	72,371	8,425	1,243,041	328,305	888	71	8	150	297	977	114	4,174,238	35,856
13 - 17	540,109	321,223	40,296	27,715	777,561	168,989	2,682	290	53	540	2,594	10,362	2,336	2,654,901	20,594
18 - 24	966,698	62,513	9,404	59,334	678,260	144,907	9,733	935	225	2,651	3,646	19,273	3,995	1,967,316	71,011
25 - 34	1,793,785	78,526	6,863	113,855	1,181,728	287,778	33,559	3,362	1,225	14,010	6,241	47,487	10,810	3,202,957	109,431
35 - 44	2,376,963	81,760	4,569	120,954	1,389,635	347,445	71,472	6,965	2,973	33,108	6,440	51,123	17,023	3,992,443	102,288
45 - 54	2,518,549	81,710	3,040	121,351	1,482,712	444,250	115,591	11,283	5,233	58,449	4,786	39,885	20,104	4,077,298	103,561
55 - 64	2,202,695	68,295	2,362	86,718	1,288,532	404,210	133,745	13,131	6,744	79,549	3,024	22,244	16,644	3,559,037	75,705
65 - 74	1,582,325	50,166	2,007	50,414	945,795	300,666	123,915	11,349	6,650	84,900	1,685	10,229	10,228	2,684,788	46,325
75+	840,021	33,884	1,250	22,213	587,239	207,495	112,687	7,899	5,241	90,150	820	3,841	4,589	1,657,378	24,485

**10.6.19 Appendix S: Number of clinical data items and Patent Charge Status April 2011 to March 2012; for England**

Patient Age Range	Teeth with Fissure Sealants	Teeth with Endodontic Treatment	Teeth with Permanent Fillings	Teeth with Extractions	Teeth with Lower Denture Acrylic	Teeth with Lower Denture Metal	Teeth with Upper Denture Acrylic	Teeth with Upper Denture Metal	Teeth with Veneers Applied	Teeth with Inlays	Number of Radiographs Taken	Number of Bridge Units	Teeth with Crowns Provided
0 - 2	440	24	9,615	4,457	123	0	502	0	3	9	894	4	29
3-5	5,540	910	368,310	82,583	57	0	1,699	8	5	15	15,143	2	397
6-12	167,128	8,701	1,866,807	505,413	686	23	5,276	137	317	923	249,697	242	1,512
13 - 17	84,216	28,522	1,181,705	309,596	1,506	98	8,191	498	3,013	9,878	683,751	5,390	11,224
18 - 24	15,706	61,652	1,150,435	186,343	9,273	664	29,136	2,328	4,161	18,541	1,235,523	8,759	31,325
25 - 34	9,932	117,843	1,855,566	391,702	64,659	4,670	143,554	11,369	7,044	45,920	2,136,343	23,263	92,703
35 - 44	5,539	123,674	1,943,315	480,359	182,441	13,144	380,669	29,464	7,151	49,494	2,288,292	37,569	148,547
45 - 54	3,250	123,474	1,992,976	623,292	390,336	26,921	749,528	56,467	5,367	38,722	2,169,451	44,670	191,867
55 - 64	2,388	87,957	1,715,589	563,518	630,169	40,382	1,056,580	79,312	3,304	21,750	1,527,106	37,277	168,273
65 - 74	2,039	51,055	1,264,304	408,937	770,335	44,202	1,133,354	78,825	1,850	10,022	846,260	22,830	104,467
75+	1,251	22,586	803,322	282,060	943,141	38,704	1,177,306	61,433	1,007	3,789	358,128	10,185	44,140

10.6.20 Appendix T: treatment demand in England 2011/12 (NHSBSA)



### 10.6.21 Appendix U: Comparison of findings on treatment need in UPDA to adult dental health survey data

The results from UPDA data were further explored in a comparative analysis of UPDA data versus ADHS data. Only where comparable variables existed in ADHS data, was a comparative analysis possible and these included age, sex and smoking status only. Data on age group related differences in treatment need were published in ADHS reports and these were directly compared with UPDA data. Smoking status and treatment need had not been analysed in ADHS reports, but the variable was present in the ADHS data set. These were therefore analysed and compared with UPDA data and presented in this section

#### Tooth restorations

Adult rate of tooth restoration at UPDA was compared with ADHS 2009 data on dental treatment received in the last course of care.

Overall 28% of adults from ADHS had received a tooth restoration at their last appointment at the dentist and 87% in their lifetime. This is compared with 54% of adults in UPDA data within the four-year study period. The findings presented in Figure 9-1 provide a description of the pattern of tooth restoration and age in the two data sets.

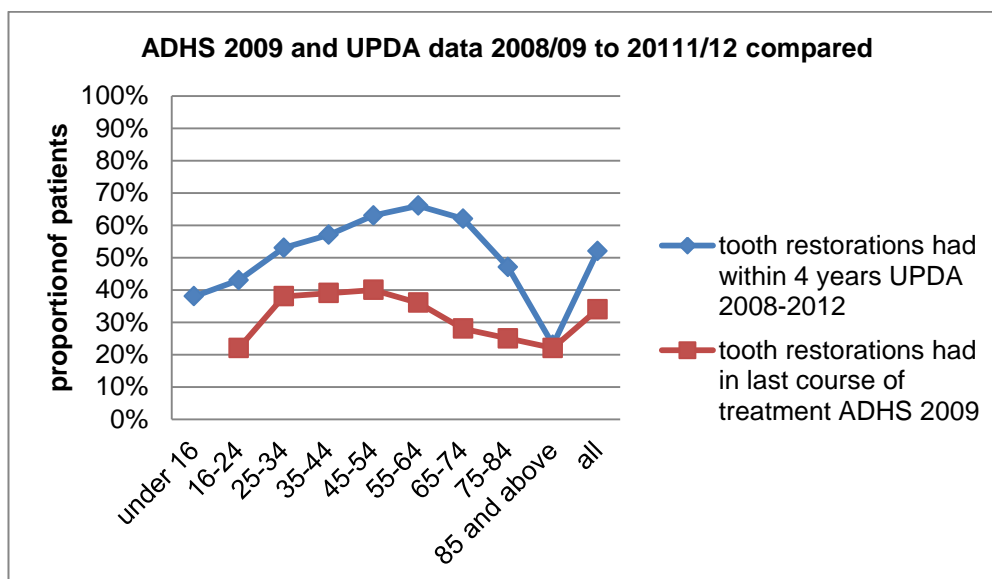


Figure 9-1 Proportion of patients who had received a tooth restoration (ADHS and UPDA)

It should be noted that the proportions are not expected to be similar for the 3 line graphs due to the difference in the time covered for each line graph (i.e. four-years for UPDA and 1 course of care for ADHS). It is however interesting to observe where the peaks and troughs exist and how these are similar in each line graph. These findings suggest a similar pattern of tooth restoration volume by age group in both data.

Adults of the age of 44-54 years and 55-64 years, commonly have the highest rate of tooth restoration treatment in UPDA and ADHS 2009 data. A proportion of 22% of patients over the age of 85 in UPDA had a tooth restoration in four-years and a similar proportion had a tooth restoration in their last appointment to the dentist in ADHS data.

A comparison of sex and tooth restoration findings from UPDA to ADHS data shows that more males had received a tooth restoration than females in their last course of care according to ADHS data and similar trend is seen in patients at UPDA within a four-year period. **Table 9-1**

**Table 9-1 Comparison of tooth restoration and sex between ADHS 2009 over 1 course of care and UPDA data over 4 years**

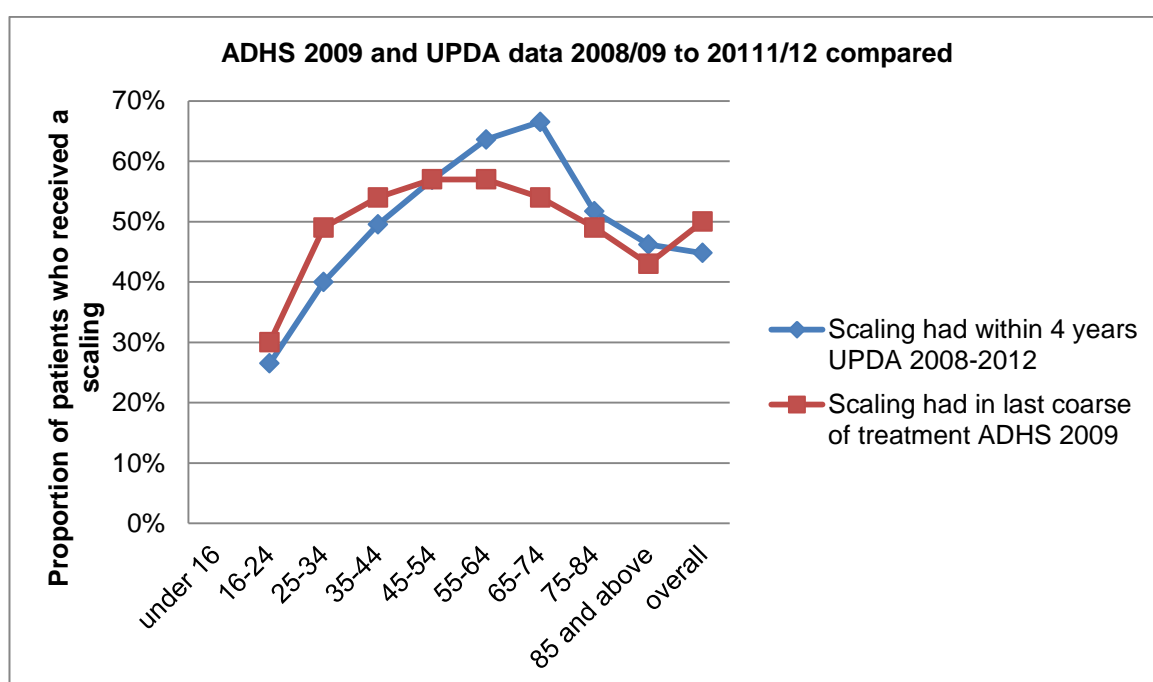
Sex	ADHS 2009 in last completed course of treatment	UPDA in courses of treatment completed within four-years 2008-2012
Female	27	51.6
Male	31	53.6

The ADHS included a variable that indicated whether a patient smoked at the present time or not. This variable was used to investigate the rate of tooth restoration among smokers and non-smokers and compared with UPDA data the results show that smokers in ADHS also had a higher proportion of patients who had received a tooth restoration compared with non-smokers.

**Table 9-2 Proportion of smokers and non-smokers who had tooth restorations in their last course of care (ADHS data) and over four years (UPDA data)**

Received a tooth restoration	ADHS 2009 in last completed course of treatment	UPDA in courses of treatment completed within four-years 2008-2012
<b>Smoker</b>	29.6	67.6
<b>Non-smoker</b>	26.2	56.7
<b>Scale and polish</b>		

Overall 50% of adults from ADHS had received a scaling at their last course of treatment, compared with 44.8% of adult patients who completed at least one treatment at UPDA over a four-year period. The proportion of adult patients, by age group, who had received of scaling in UPDA compared with ADHS 2009 data shows a similar trend, however the rates of scaling among 55-64 year olds and 65-74 year olds is highest in UPDA compared with ADHS data which shows that



The proportion of adult smokers who had received a scaling as part of their last course of care according the ADHS data was lower than non-smokers this is the opposite relationship to the

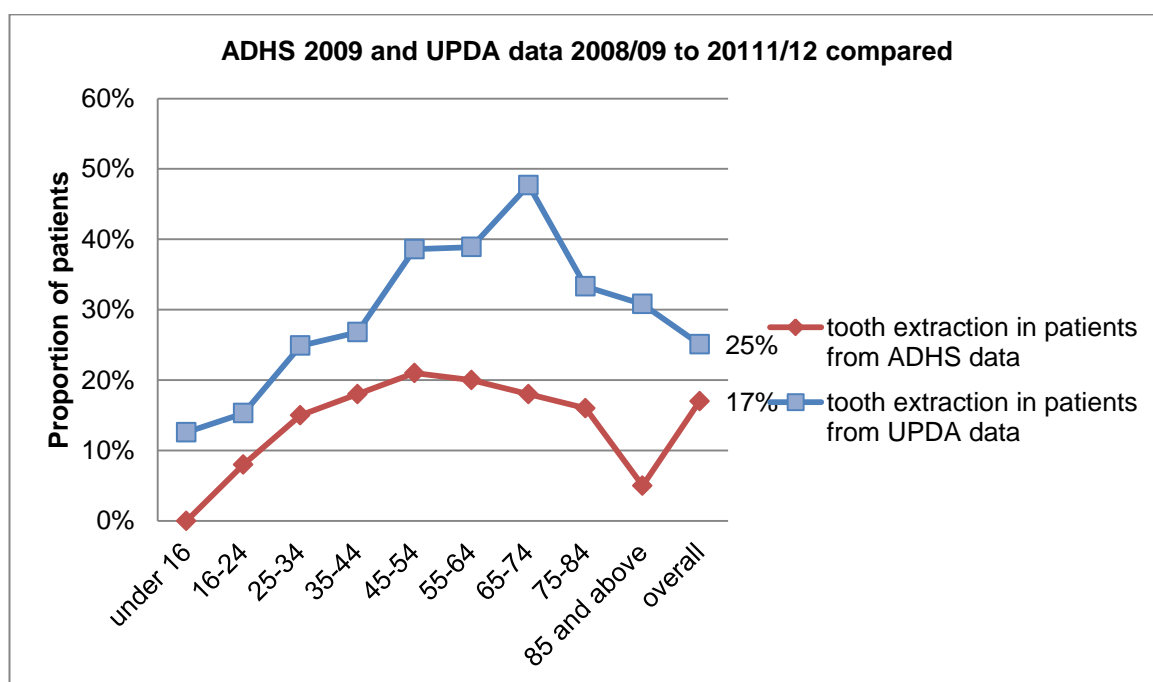
findings from UPDA. ADHS findings is however not a statistically significant difference  $p=0.083$ , while the difference shown in UPDA is statistically significant.

**Table 9-3 Proportion of patients who had a scaling by smoking status (UPDA and ADHS data compared)**

Received a scaling	in last completed course of treatment (ADHS 2009)	in courses of treatment completed over four-years 2008-2012 (UPDA)
<b>Smoker</b>	46.7	68.5
<b>Non-smoker</b>	48.5	56.5

#### Tooth extractions

25% of UPDA patients over four years, compared with 17% of ADHS patients in the last treatment plan had received tooth extraction. The trend in the rate of extraction at UPDA is highest for 65-74 year while in ADHS data the highest peak is among the 45-54 year olds.



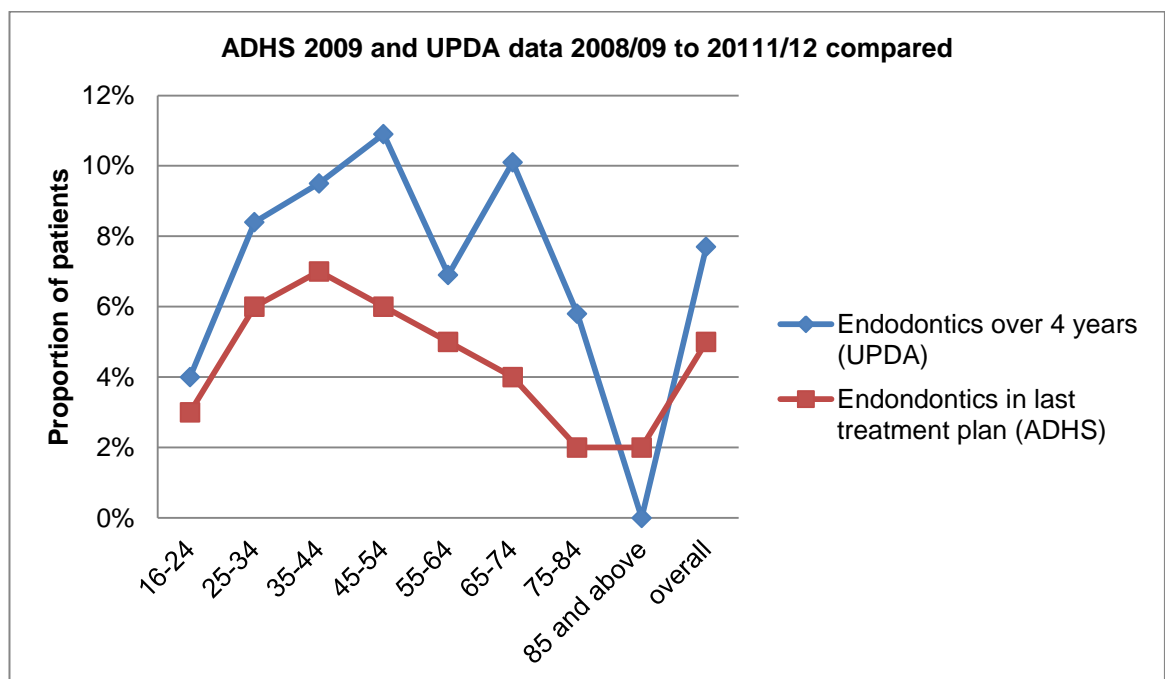
**Figure 9-2 Proportion of patients who received a tooth extraction comparing UPDA data and ADHS 2009**

Smokers in the ADHS data had a significantly higher rate of extraction occurrence 25.2% compared with non –smokers 14.6%  $p=0.001$ . Although the rate is higher in UPDA the proportion differences are similar in pattern as smokers also have a higher rate of extraction than non-smokers at UPDA.

**Table 9-4 Comparing tooth extraction UPDA data and ADHS data**

Received a tooth extraction	in last completed course of treatment (ADHS 2009)	in courses of treatment completed over four-years 2008-2012 (UPDA)
<b>Smoker</b>	25.2	39.8
<b>Non-smoker</b>	14.6	24.3
<b>Endodontics</b>		

Overall 5.2% of patients in ADHS data had received endodontic treatment as part of their last completed course of care, compared with 6.6% over four years in the UPDA data. The age group distribution of endodontic treatment is shown in Figure 9-3



**Figure 9-3 Proportion of patients who received an endodontic treatment comparing UPDA and ADHS 2009**



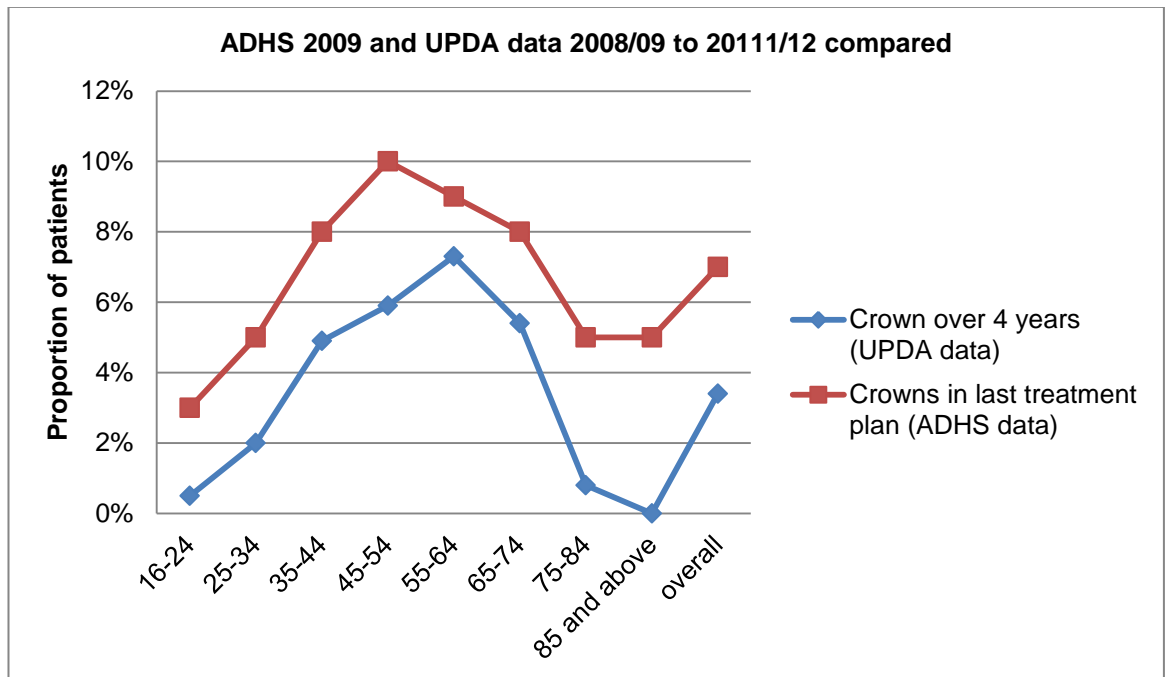
Smokers from the ADHS data had a higher proportion of patients who had received an endodontic treatment, similar to patients in the UPDA data. **Table 9-5**

**Table 9-5 Comparing occurrence of endodontic treatment by smoking status in UPDA data and ADHS data**

Received an endodontic treatment	in last completed course of treatment (ADHS 2009)	in courses of treatment completed over four-years 2008-2012 (UPDA)
Smoker	5.8	39.8
Non-smoker	4.9	24.3

## Crowns

Crowns were part of the last treatment plan in the ADHS data for 7 %, while they were part of the treatment over four years for 4.5% of the patient population at UPDA. The occurrence of crowns as part of the last completed treatment plan varied across age groups in both UPDA and ADHS data.



**Figure 9-4 Proportion of patients who received a crown UPDA and ADHS compared**

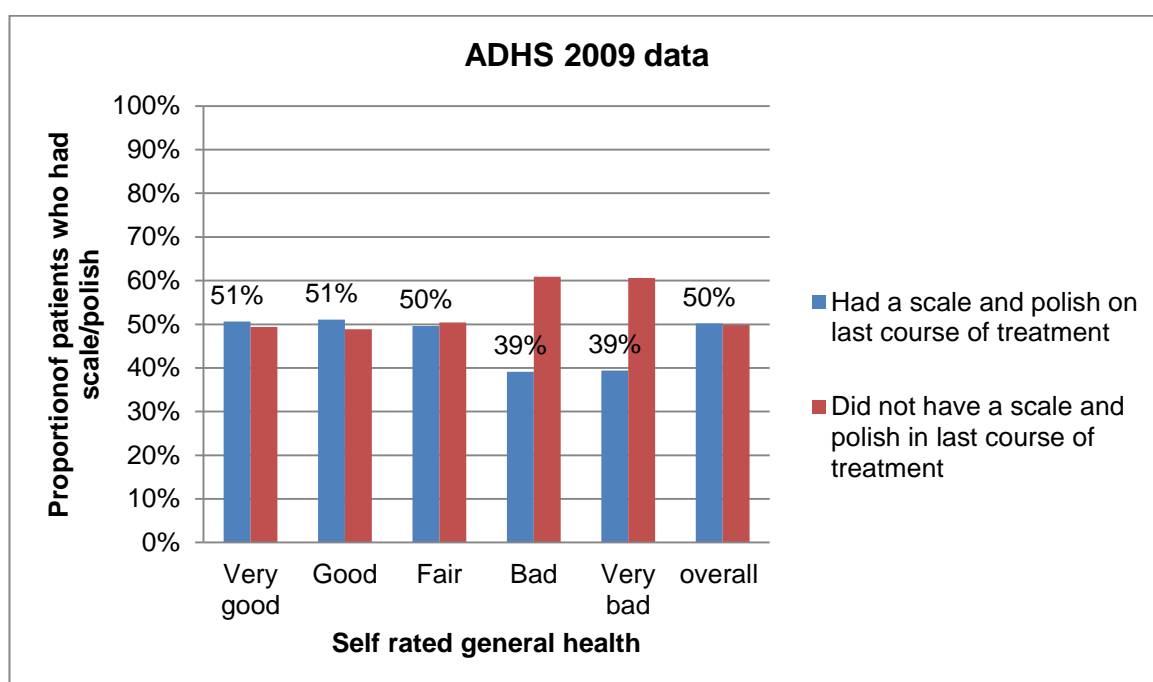
The proportion of patients who had crowns showed a similar trend in both data sets. The highest rate in the ADHS data among the 45-54 year olds and the highest in UPDA data being the 55-64 year olds

Crowns were more common in smokers within the UPDA data 5.7% compared with 4.2% non-smokers. In ADHS data, the relationship between these two variables was in the reverse, with non-smokers having a higher proportion of crowns within a four-year period (7.2%) compared with smokers (6.5%)

### Area level measure and treatment need

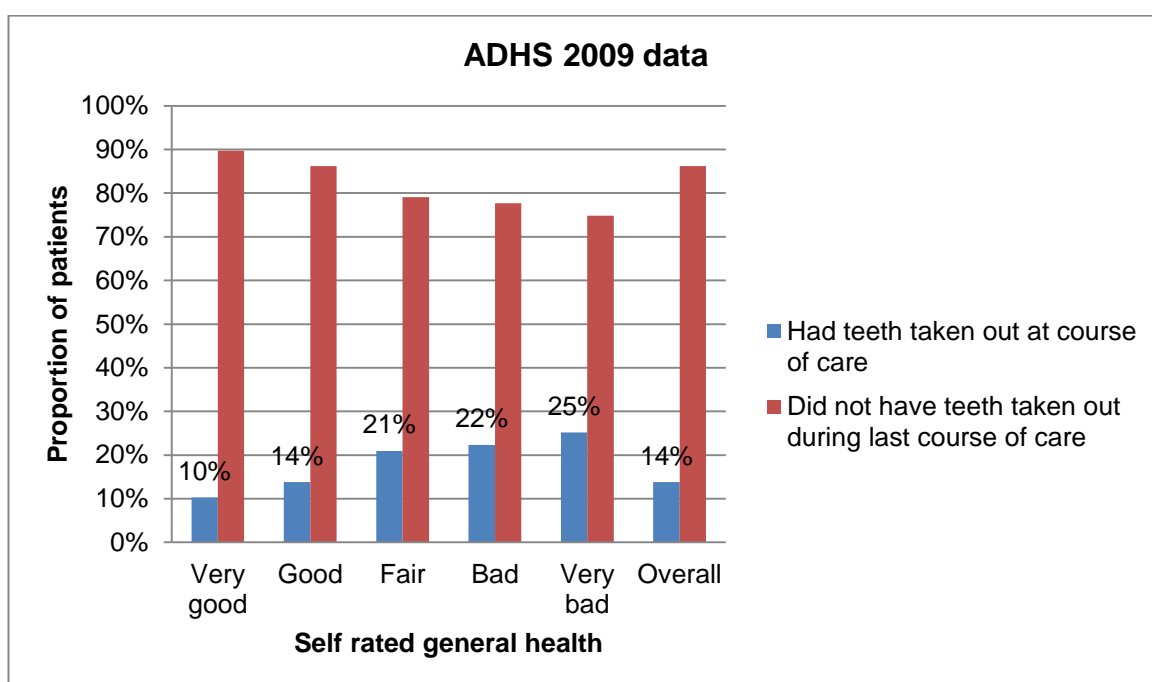
UPDA data suggested that area of residence has a small effect on the rate of occurrence of tooth extraction and scale/polish. In addition a higher health deprivation score significantly increased likelihood of having had an extraction and reduced likelihood of having had a scale/polish. In ADHS data, there were no post codes or quintiles of deprivation in PCT however; there was a self-rated general health question. ADHS data was therefore investigated further to ascertain whether self-rated general health was associated scale/polish or tooth extraction.

The results in **Figure 9-5** show that those who rated their general health as poor had lower rate of scale and polish occurrence in ADHS data, suggesting a similar pattern as the UPDA data. With overall rate of scale/polish at 50% in the whole sample, only 39% of patients who felt their general health was bad or very bad had received a scale and polish in their last course of treatment. These differences were statistically significant on chi square test of significance  $p=0.001$ .



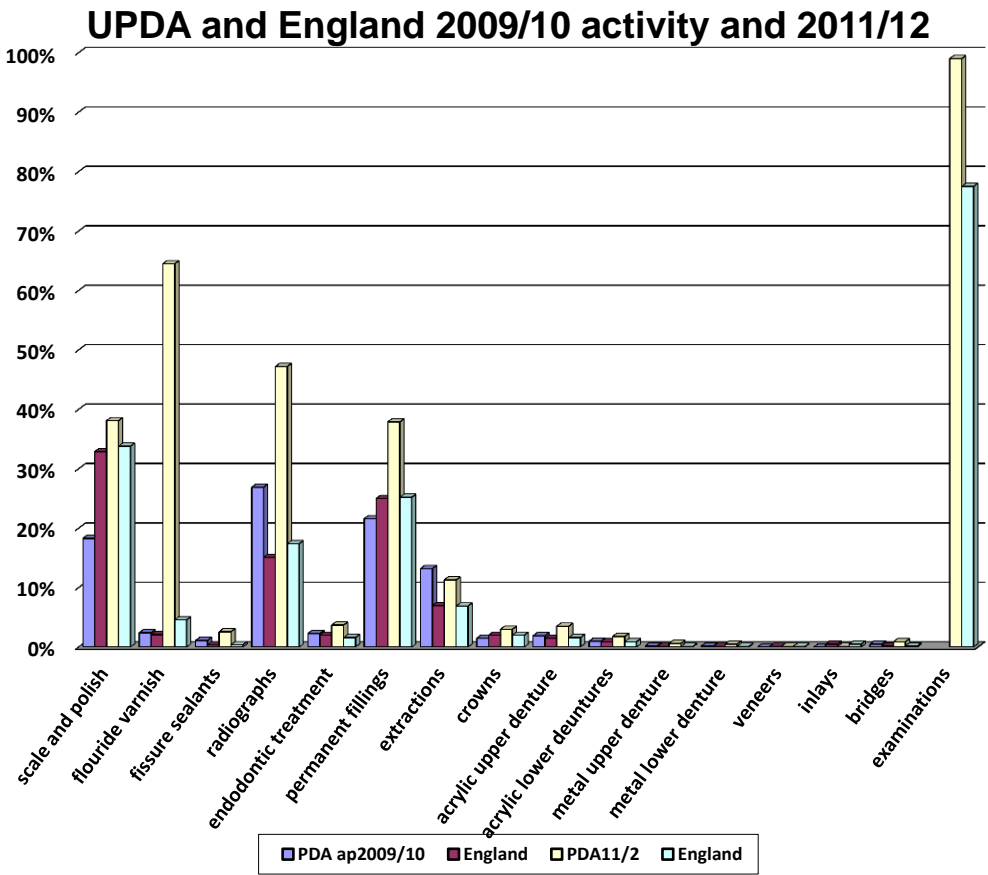
**Figure 9-5 Proportions of patients who had scale/polish in last dental visit ADHS 2009 by self-rated general health**

Tooth extractions were shown to have a significant association with health deprivation in UPDA data, with a higher deprivation score increasing the likelihood of having had an extraction by 22%. The descriptive analysis of ADHS data showed that, patients who had rated their general health bad had a higher proportion of patients who had tooth extraction than patients who had good or very good health. See **Figure 9-6**. These differences were statistically significant on chi square test of significance  $p=0.001$ .



**Figure 9-6 Proportion of patients who had tooth extractions as last course of care ADHS 2009 by self-rated general health**

10.6.22 Appendix V: Comparing NHS dental service activity [UPDA and England] 2009/10 and 2011/12



## RESEARCH

## Open Access

# Dental skill mix: a cross-sectional analysis of delegation practices between dental and dental hygiene-therapy students involved in team training in the South of England

Kristina L Wanyonyi<sup>1\*</sup>, David R Radford<sup>2,3</sup> and Jennifer E Gallagher<sup>1</sup>

## Abstract

**Background:** Research suggests that health professionals who have trained together have a better understanding of one another's scope of practice and are thus equipped for teamwork during their professional careers. Dental hygiene-therapists (DHTs) are mid-level providers that can deliver routine care working alongside dentists. This study examines patterns of delegation (selected tasks and patients) by dental students to DHT students training together in an integrated team.

**Methods:** A retrospective sample of patient data ( $n = 2,063$ ) was extracted from a patient management system showing the treatment activities of two student cohorts (dental and DHT) involved in team training in a primary care setting in the South of England over two academic years. The data extracted included key procedures delegated by dental students to DHT students coded by skill-mix of operator (e.g., fissure sealants, restorations, paediatric extractions) and patient demography.  $\chi^2$  tests were conducted to investigate the relationship between delegation and patient age group, gender, smoking status, payment-exemption status, and social deprivation.

**Results:** A total of 2,063 patients managed during this period received treatments that could be undertaken by either student type; in total, they received 14,996 treatment procedures. The treatments most commonly delegated were fissure sealants (90%) and restorations (51%); whilst the least delegated were paediatric extractions (2%). Over half of these patients (55%) had at least one instance of delegation from a dental to a DHT student. Associations were found between delegation and patient age group and smoking status ( $P < 0.001$ ). Children under 18 years old had a higher level of delegation (86%) compared with adults of working age (50%) and patients aged 65 years and over (56%). A higher proportion of smokers had been delegated compared with non-smokers (45% cf. 26%;  $P < 0.001$ ).

**Conclusions:** The findings suggest that delegation of care to DHT students training as a team with dental students, involved significantly greater experience in treating children and adult smokers, and providing preventive rather than invasive care in this integrated educational and primary care setting. The implications for their contribution to dentistry and the dental team are discussed, along with recommendations for primary care data recording.

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## Background

The current position paper of the World Health Organization on scaling up the health workforce considers inter-professional training as an essential step in the development of a collaborative health workforce [1]. In both developed and developing countries, the concept of collaborative practice within the dental team is encouraged, particularly through task sharing and wider use of mid-level dental providers [2-5]. There are several cadres of mid-level dental providers; collectively, they are often referred to as dental care professionals (DCPs) or dental auxiliaries, and include dental hygienists, dental nurses, orthodontic therapists, dental hygiene-therapists, clinical dental technicians, and dental technicians [6].

In recent times, the developing role of dental hygiene and dental therapists has gained wide interest [7-9]. This is because many see potential for improved capacity of dental services through task sharing between dentists and other members of the dental team due to their overlap in skills [10,11]. In the UK, there has been a recent move to train dually qualified dental hygiene-therapists [12]. The scope of practice of a dental hygienist is within that of a dental therapist [13], and, when qualified, dental therapists may register and work as a dental hygienist and as a dental therapist. The equivalent personnel who have training to the level of a dental therapist are referred to differently between countries; for example, dental therapists (New Zealand, Malaysia, and USA) [10]; oral health technicians (Brazil) [14]; oral health therapists (Holland) [10]; and dental hygiene-therapists or dental therapists (UK) [6]. The development of their role or scope of practice and the regulation of their practice also vary between countries. These variations mainly revolve around the 'level of autonomy' and 'scope of practice' [14,15]. These personnel commonly provide routine care that includes scaling, filling cavities, preventive care, and extraction of children's teeth [16].

In The Netherlands and the UK, the training of hygienists, who mainly work in clinical prevention, has been expanded into dually qualified hygiene-therapists [10,12]. In Scandinavian countries, where there are hygienists but no hygiene-therapists, researchers have suggested that the training of hygienists should be expanded to provide them with sufficient skills and the confidence to carry out a greater variety of clinical treatment measures in the future [2]. The rationale behind these changes appears to be to give more time for dentists to cope with increased demand for complex treatments and care for medically compromised patients; these factors are associated with the changing demands and increasingly ageing populations whilst also recognising general improvements in oral health and that some more simple tasks may be delegated to other members of the dental team [10,17,18].

In the UK, the General Dental Council (GDC), as the regulating body, has outlined the roles and responsibilities of all dental professionals, including dental therapists in the GDC 'Scope of Practice' guidance [13], and they have recently approved the concept of 'Direct access' for patients to dental hygienists and dental therapists [19]. This regulation falls in line with other contemporary government policies that have encouraged a team approach to primary dental care services in order to meet the changing demands on dental services [20]. This follows several decades of documents calling for wider use of DCPs, task sharing, and skill mix [21]. Despite such lengthy support, DCPs, particularly those holding a dental therapy qualification, appear to be underutilised [12,15].

Research in the UK to ascertain the reasons for the underutilisation of dental hygiene-therapists has revealed a lack of understanding and misconceptions over their scope of practice amongst dentists [22-26]. Evidence from Brazil suggests that lack of autonomy and credibility with the public has led to challenges in developing the role of oral health technicians [14]. In the USA, whilst dental therapists have developed in many states, they have continued to face opposition from national and state dental associations [27]. In Scandinavia, developing the scope of practice of hygienists also remains an issue of debate [2].

The economic implications of using dental hygiene-therapists have also been the subject of debate [28,29]. Sun et al. [29] found that although some practices have found ways to incorporate dental hygiene-therapists in their practices, practice principals find it challenging to evaluate their contributions and plan for payments, because there is lack of management information on their productivity.

In regards to acceptability of dental hygiene-therapists, there is evidence that the public and patients in the UK find them acceptable, but knowledge of their roles is unclear and further education of the public is suggested [30,31]. As the number of dental hygienists-therapists in training has expanded, consideration is increasingly being given to developing multi-professional training. Ross et al. [10] suggest that dental students who have been trained together with DCPs have a better understanding of DCPs scope of practice than those who have not. It is therefore important that there is a clear understanding of respective roles of the members of the dental team to further develop skill mix in practice.

As the agenda to promote teamwork, skill mix, and task delegation continues, a clear call for more empirical data on the contribution dental hygiene-therapists make to clinical care has been made [11,29]. Apart from one observational study in primary dental care by Evans et al. [11] in general dental practices in South Wales, little is known about patient delegation within the state funded health system in the UK and there is no published information on what happens when dental and dental

hygiene-therapy students train together. This study seeks to inform this knowledge gap by contributing findings that will be useful in aiding the understanding of how delegation can work within the dental team in training and analysing data from a patient management system that is common to primary dental care nationally.

This research aimed to examine the activities of a team of dental and dental hygiene-therapy students training together in an integrated team-training primary care environment in the South of England, where barriers to delegation placed by the payment system do not exist. In particular, the analysis focuses on the patterns of delegation of tasks from final year dental students to dental hygiene-therapy students. The dental students, who are under the supervision of tutors, examine and formulate care plans that may involve delegation to dental hygiene-therapy students. This is an initial approach to inform a quantitative knowledge gap, using statistical analysis to show magnitude and distribution of delegation and by itself does not answer all questions about delegation, which would include wider elements, features, facilitators, and hindering factors of delegation.

## Methods

The facility at the centre of this research is the University of Portsmouth Dental Academy (UPDA) in the South of England. It is a primary care dental training centre opened in September 2010 to integrate education and training of dental students on outreach training from King's College London with DCPs (dental hygiene-therapy and dental nursing students) training in Portsmouth. The facility was expanded in order to improve both service capacity for the surrounding community and enhance teamwork training in dentistry, having previously only hosted the training of DCPs in any given week, 20 dental students worked three and a half clinical days with 2<sup>nd</sup> and 3<sup>rd</sup> year dental hygiene-therapy students (24 per cohort) undertaking two days of clinical work per student.

This research was conducted using retrospective cross-sectional patient data obtained from the electronic patient management system at UPDA. The findings presented here form part of a wider body of research that looks into case mix and skill mix at UPDA as well as access to dental care [32]. Ethical Approval was given by NRES Committee Fulham REC: Reference No. 11/LO/1138 Protocol No. NTMHWMOV3 and NHS Portsmouth R&D Committee Reference No. SSPS/05/11.

The data comprised patient demography and treatment activity in the first 2 years of team training (1 September 2010 to 31 August 2012). Clinical activity included treatment item codes, which indicated the performer of the treatment (dental student or dental hygiene-therapy student). For example, an amalgam restoration would be coded either amalgam restoration for dental student [Amalgam

filling-DS] or amalgam restoration for dental hygiene-therapy student [Amalgam filling-HTS], depending on the type of student. This coding structure was part of the patient management software modified by UPDA. Dental students undertook patient assessments and treatment planning including whether or not a treatment should be delegated to a dental hygiene-therapy student, and coded the care accordingly. Dental students had the freedom to delegate tasks within the dental hygiene-therapists scope of practice.

All data on patients who had one or more procedures, labelled by provider of care, were eligible for analysis ( $n = 2,063$ ). These included paediatric tooth extractions (related to disease or exfoliation), restorations, pulp-tomies (endodontic treatment on primary teeth), fissure sealants, and urgent care. Other less complex clinical items which may be delegated were not coded by provider of care within the patient management system, most notably scale and polish and fluoride varnish, and thus were not available for skill mix analysis.  $\chi^2$  tests were applied to examine the relationship between delegation to dental hygiene-therapy students and patient socio-demographic characteristics; this included patient ethnicity, age, gender, payment status, smoking status, and quintile of deprivation.

Age was analysed in age-groups. First, in three categories 'under 18 years', '18–64 years' (working age adults), and 'over 64 years'. A further analysis of the distribution of delegation by age was undertaken using the 11 National Health Service (NHS) age-groups (0–2 years, 3–5 years, 6–12 years, 13–17 years, 18–24 years, 25–34 years, 35–44 years, 45–54 years, 55–64 years, 65–74 years, Over 75 years).

Payment status identifies whether a patient is exempt from charges or not within the NHS system, albeit that in this educational setting charges did not apply. Adults of different social circumstances, for example, receiving unemployment benefit, are exempt from payment [33]. All children are automatically exempt from payment in line with the policy in state funded dental care in England; therefore, only adult payment exemption status was analysed in this study. Smoking status and whether a patient was signposted for smoking cessation are automatically collected in the patient management system as clinicians are required to collect this information as part of the payment contract and in support of delivery of preventative care. Quintiles of deprivation were calculated based on the Index of Multiple Deprivation (IMD) score, a measure that provides a relative measure of deprivation at small area level across England [34].

## Results

### Patient characteristics and delegation

There were 2,063 patients and a total of 14,996 treatment procedures in the study data set; 55% (1,134) of patients had evidence of at least one instance of delegation. There



were statistically significant relationships between delegation and patient characteristics (Table 1). Younger patients were delegated to dental hygiene-therapy students at a higher rate than other groups ( $P < 0.001$ ), with the majority of patients under the age of 18 years (86%) having been delegated at least once, compared with 54% of older adults ( $\geq 64$  years) and 50% of working age adults (18–64 years). A higher proportion of smokers had been delegated, compared with non-smokers (45% cf. 26%;  $P < 0.001$ ). No significant difference was found in the proportion of patients delegated by gender, quintile of deprivation, or payment status.

#### Patient age and delegation

The relationship between age and delegation was examined further by 11 age groups (Figure 1), and the findings indicate that a larger proportion of younger patients were delegated compared to older aged patients; this ranged from 100% of 3–5 year olds delegated compared to only 44% of 18–24 year olds. Amongst adult patients, the 35–44 year age-group had the highest level of delegation (55%).

#### Treatment type and delegation

Overall, 46% of the treatments in the data set analysed were delegated. The procedures most commonly delegated

were fissure sealants (90%), restorations (52%), and pulp-tomies (endodontic treatment on primary teeth) (51%). The least delegated operations were paediatric tooth extractions (2%) as outlined in Figure 2. Procedures involving management of soft tissue mucosal lacerations or bleeding, classified as urgent, were performed by dental students.

#### Discussion

The findings of this study provide insight into the pattern of delegation from dental students to hygiene-therapy students during training, with analysis restricted to the higher level of treatments within the scope of practice of dental hygiene-therapists. The data suggest that, in this educational establishment, 46% of these higher level treatments and 55% of patients receiving this care were delegated by the dental students to dental hygienist-therapy students. Overall, dental hygiene-therapy students delivered a higher proportion of preventative tasks and undertook a significantly higher proportion of care on children and adult smokers. The findings do, however, need to be considered within the context, which is a state-funded primary care educational facility in the South of England where patient charges for adults were not applied. Furthermore, it is important to recognise that the findings are an under-representation of the overall clinical

**Table 1 Differences in delegation rate by patient socio-demography**

	Row total	No delegation		Delegation		P value
		n	%	n	%	
<b>Delegation Overall</b>	<b>2,063</b>	<b>929</b>	<b>45.0</b>	<b>1,134</b>	<b>55.0</b>	
<b>Gender</b>						
Female	926	419	45.2	507	54.8	0.447
Male	1,137	510	44.9	627	55.1	
<b>Payment status (adults only; n = 1,740)</b>						
Non-exempt	1,569	798	50.5	776	49.5	
Exempt	171	83	48.5	88	51.5	0.630
<b>Age groups</b>						
Under 18 years	282	41	14.5	241	<b>85.5</b>	<b>0.001*</b>
Working age (18–64 years)	1,567	789	50.4	778	<b>49.6</b>	
Over 64 years	214	99	46.3	207	<b>53.7</b>	
<b>Quintiles of deprivation based on patient population (n = 2,043)</b>						
Most deprived 1	445	200	44.9	245	55.1	0.988
2	423	192	45.4	231	54.6	
3	483	222	46.0	261	54.0	
4	450	199	44.2	251	55.8	
Least deprived 5	241	108	44.6	134	55.4	
<b>Smoking cessation signposting (adults only; n = 541)</b>						
No	196	145	74.0	51	<b>26.0</b>	<b>0.001*</b>
Yes	345	191	55.4	154	<b>44.6</b>	

\*Statistically significant differences in bold; n = 2,063 unless otherwise stated.

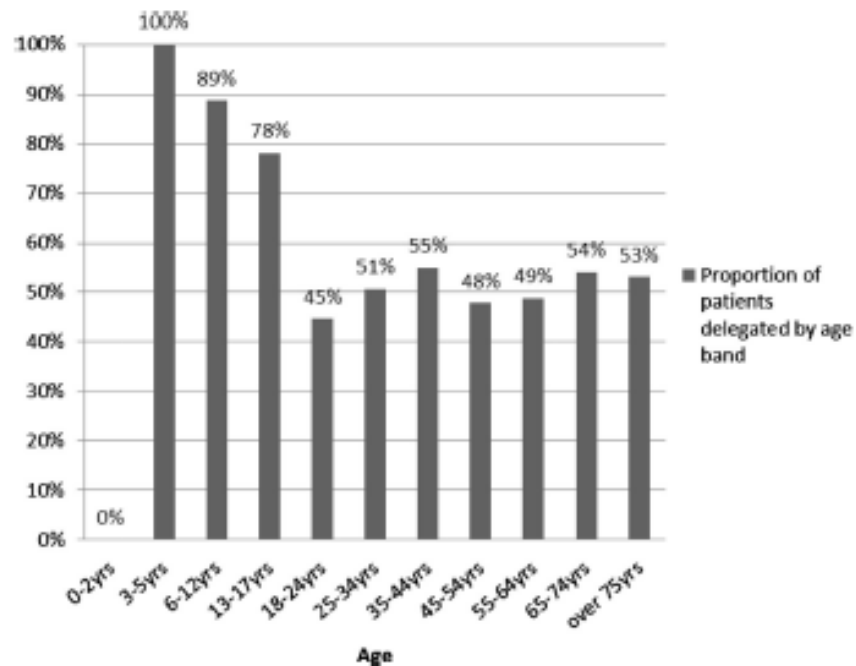


Figure 1 Proportion of patients delegated by age group.

care provided by the dental hygienist-therapists students, as some simple elements of care were not coded by skill mix and attributed to them in the management system.

The high rate of delegation of children (86%) compared with adults (50% of 18–64 years old and 54% of ≥65 years

old) could be attributed to a number of factors. First, the more widely accepted and traditional role of the dental hygiene-therapist in children's care; since the first dental therapists were introduced to work in school dental services in New Zealand [35] the perception that those with

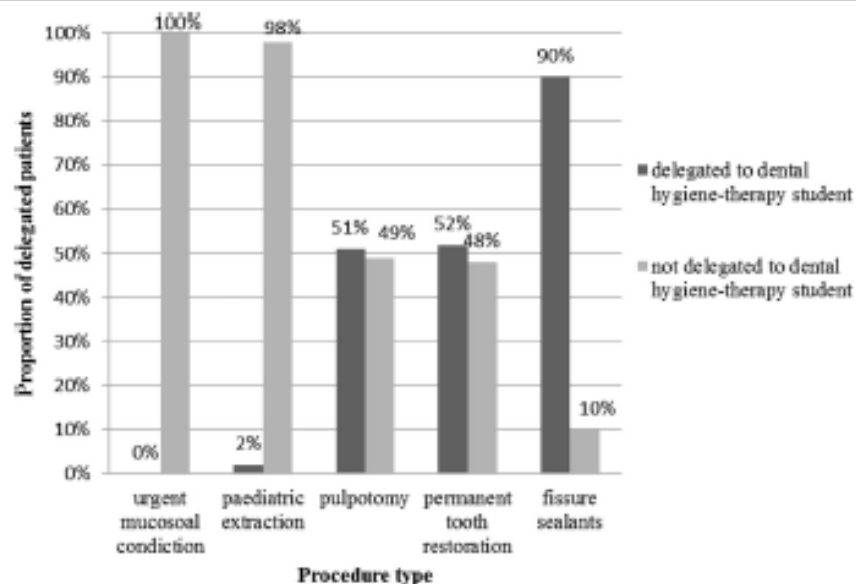


Figure 2 Rate of treatment delegation from dental students to hygiene-therapy students.

therapy training are well suited to caring for children has persisted. Second, given this is an educational establishment, the need for students to gain certain clinical experience undoubtedly plays a role; dental hygiene-therapy students only have the opportunity to treat children at UPDA, whilst dental students do so in other settings. The findings, therefore, demonstrate that hygiene-therapists gain experience in children's care. This is important as they move forward in their careers as various studies suggest there are gains to be made in patient outcomes and productivity through their utilisation in children's care [36,37].

Moving on to the rationale for the delegation rate of adult care, the lower level of delegation amongst adults may be attributed to a number of factors. First, 'scale and polish', a common component of adult care, was not coded by provider of care and therefore could not be included in the analysis. This may have reduced the potential for a large number of adult patients who had been delegated for that procedure from being included in the analysis. Second, adult patients may have required more complex overall care, therefore necessitating the additional knowledge and skills of a dentist. Third, dental students at this level need experience of more complex procedures, e.g., endodontic treatment, fixed and removable prosthodontics, and so may be more selective in focusing their clinical time on complex tasks required by patients and delegating routine care.

This patient management system data revealed that preventative care which was well within the scope of a dental hygiene-therapist was delegated at a higher rate than restorative tasks. While still considering prevention, it is noteworthy that the contribution of dental hygiene-therapists to health promotion, including clinical prevention, is considered vital for contemporary evidence-based care [38,39]; this includes items such as fissure sealants [40]. Furthermore, the experience gained by these students in prevention programmes, therefore, places them in an ideal position to participate in prevention, particularly as policy makers in England are placing greater emphasis on targeted public health programmes [41] and clinical prevention [42]. In countries such as Brazil, oral health technicians, with a similar scope of practice, have found an invaluable place in the provision of public health programmes [14].

These findings suggest that a significantly higher proportion of smokers than non-smokers were delegated to dental hygiene-therapists for clinical treatment. According to the system of practice at UPDA, patients identified as smokers are signposted to smoking cessation services. Dental team members do not provide specific smoking cessation counselling nor are they able to prescribe aids to cessation such as nicotine replacement therapy, etc. The fact that a large number of smokers are

treated by dental hygiene-therapy students highlights opportunities for health messages, including more specific smoking cessation support, and thus contributes to the management of common risk factors [43]. Evidence from the US, UK, and Australia suggests that dental hygienists and dental hygiene-therapists can successfully play a role in providing smoking cessation counselling [44-46].

This analysis reveals vital information on the delegation pattern for a range of restorative tasks, which are within dental therapists' scope of practice, but notably are not as widely performed once qualified [47,48]. The findings compare broadly with those of Evans et al. [11], who suggest that a significant amount of care (35% of care visits and 43% of clinical time) could be delivered by trained dental hygienists and therapists. However, there is evidence that qualified dental hygiene-therapists in the UK undertake more simple hygiene than therapy work, which is a possible concern as it may lead to deskilling [48]. It is worth noting that dental hygiene-therapists' scope of practice supports their working in either role allowing them to deliver both routine restorative work and periodontal care to adults [13], as well as prevention.

This study focused on the recorded clinical experiences gained by both dental students and dental hygiene-therapists when trained together, and thus provides insight into their preparation for future practice. Although the study has limitations due to the inability to analyse total procedures delegated in the 2 year period, it does provide clear quantitative insight to a model of skill mix. Furthermore, this is an educational facility where curricula and learning may play a part in determining who provides what care in the dental team; however, the possibility that these early professional behaviours may influence future professional working patterns should be considered. For the educational facilities, the knowledge of the range and type of patients treated by dental hygiene-therapists, especially risk groups such as smokers, is useful in planning training of the students in health promotion.

Further research is required to understand when and why students in training delegate or refer on particular treatments or patient groups. There is also room to explore how different models of skill mix and delegation rate relate to demand for care.

As mentioned above, one limitation of this study was that not all care was coded by the provider in the patient management system and thus limited the analysis; therefore, it is recommended that all primary care patient management systems should apply codes to indicate which type of operator provided care, so that a greater understanding of skill mix can be gained. This small change would provide additional insight to primary dental care working practices, both current and future.



# Conclusions

The findings suggest that delegation of care to dental hygiene-therapy students in team training with dental students, involved significantly more experience in treating children and adult smokers, and providing preventive rather than invasive care during their clinical training in an integrated educational and primary care service. Educators and planners of dental services seeking to improve and understand the use of dental team skill mix, should consider coding all treatment items in patient management systems, by type of operator, in order to facilitate a wider understanding of the clinical experience and productivity of different members of the dental team in the provision of patient care.

# Abbreviations

DCPs: Dental care professionals; GDC: General Dental Council; NHS: National Health Service; UPDA: University of Portsmouth Dental Academy; DHT: dental hygiene-therapy.

# Competing interests

DRR is Director of Clinical Studies for the Dental Students at UPDA, whilst JEG leads Dental Public Health teaching across the Institute and KLV contributes to the undergraduate dental teaching programme.

# Authors' contributions

KLV participated in study design, conducted the research, and prepared the manuscript. DRR was involved in the research coordination and contributed to the manuscript. JEG participated in the study design, supervised the research, and contributed to the manuscript. All authors read and approved the final manuscript.

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## Original Research

# The relationship between access to and use of dental services following expansion of a primary care service to embrace dental team training

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## ABSTRACT

**Objectives:** To investigate changes in the patient population and treatment case-mix within an expanded primary care dental training facility in Southern England.

**Study design:** Cross-sectional analysis of patient management system data.

**Method:** Electronic data for patients with a closed/completed treatment plan in the 12-month period prior to, and following, dental service expansion were extracted for analysis ( $n = 4343$ ). Descriptive analysis involved age, sex, payment status, deprivation status and treatment activity. Logistic regression was used to model the likelihood of treatment involving laboratory constructed devices (crowns, bridges, dentures), in relation to demography and deprivation in each time period.

**Results:** The volume of patients using the service increased by 48.3% (1749 of 2594). The average age increased from 31.97 (95%CI: 30.8, 32.5) to 36.4 years (95%CI: 35.6, 37.1); greatest increase was in the over 75 years age-group (96%). The patient base became less deprived: patients exempt from payment reduced from 43.2% ( $n = 755$ ) to 28.6% ( $n = 741$ ) ( $P = 0.001$ ) and the mean population deprivation score (PMD) reduced from 24.5 (95%CI: 23.8, 25.2) to 22.3 (95%CI: 21.7, 22.8). The volume and proportion of cases involving laboratory constructed devices increased from 8.3% ( $n = 145$ ) to 15.8% ( $n = 411$ ) whilst assessments without interventional care decreased (34.5%–26.3%). On a logistic regression, the odds of having treatment involving laboratory constructed devices, increased with increasing age in both time periods 7% (95% CI: 1.06–1.08) and 6% (95% CI: 1.05–1.07) respectively. Furthermore, the odds increased by 38% OR: 1.38 (95% CI: 1.01–1.89) in period 2, for white patients. After adjusting for these effects, the odds of having care that involved laboratory constructed devices were less in period 2 than period 1 (100% of 43%) for those who were technically exempt from payment (OR = 2.0; 95% CI 1.34 to 2.90 cf, OR = 1.43; 95% CI 1.13–1.81).

**Conclusion:** The patient population altered in relation to age and socio-economic status. The expanded service had greater uptake by older people while users were less likely to be

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deprived. The expanded service, free at the point of delivery, attracted a higher proportion of patients who would normally have to pay health service charges. The service also showed an increase in treatment case-mix that involved laboratory constructed dental devices.

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## Introduction

Ensuring equitable access to dental services is an important element of dental service planning.<sup>1–3</sup> In countries including the United States of America [US] and the United Kingdom [UK], dental access and utilization rates have been shown to indicate disparities.<sup>4,5</sup> These disparities in access rates could be attributed to multifaceted factors, which are social, financial, geographical and attitudinal.<sup>6,7</sup> Research has shown that psychosocial factors such as age, gender, socio-economic status, attitudes, location of services and anxiety play a role in utilization of dental services.<sup>2,7–10</sup> This evidence has led governments and stakeholders into considering the local needs of a population when planning service delivery, thus improving dental service uptake and oral health.<sup>11,12</sup>

Planning dental services that are geared to the local needs of the population, involves considering changing disease levels and demography. These factors have been shown to have an impact on the nature of dental treatment required by a population.<sup>13,14</sup> Research has supported these findings by indicating that the increasingly ageing population in developed countries requires more advanced treatment services.<sup>15,16</sup> These advanced treatments could include provision of laboratory constructed devices such as crowns and dentures.

Poor socio-economic status has been long associated with inequalities in oral health and poor access to dental services amongst deprived communities further exacerbates the problem.<sup>16,17</sup> It is suggested that to encourage potential users to take up new health services, planners need to involve users in the service development process.<sup>18</sup> Helplines have been used to improve health service utilization for users with poor dental access; however, these approaches have been recognized as having limitations and may contribute to widening inequalities.<sup>19</sup> It is recommended that when informing consumers about health services, providers should also take into account the literacy of consumers, accessibility and comprehensibility of the information.<sup>18</sup>

This study is focused on an expanded primary care dental training Academy in Portsmouth in the South of England. The Academy was expanded to integrate education and training for dental students in an outreach setting with dental care professional students (Dental Hygiene and Therapy and Dental Nursing students); this was in order to improve both service capacity for the surrounding community and teamwork in dentistry. For a period of five years before the facility was expanded into the integrated dental academy, only dental care professionals were trained; and they received patients by referral from salaried dentists. The area surrounding the facility required increased dental service capacity, due to poor dental access rates, oral health inequalities and pockets of

great deprivation. Estimated dental access rates in the most deprived wards in the city are as low as 42% for children and 45% for adults; both are lower than the local averages (57%). Furthermore, the age groups 0–2 years, 18–24 years and over 75 years all show poor attendance rates.<sup>20</sup>

The expanded Dental Academy (one single site) holds a service contract with the local NHS (state funded dental care). The contract aim was to increase service availability for the local population and thus support access to dental care. The dental software in the outreach facility codes treatments according to the national NHS banding system; Table 1 provides an overview of the standard NHS Bands and treatments included. In the period after the facility was expanded there has been an increase in service capacity from three salaried dentists to 20 final year dental students every week during academic terms. The expanded facility hosts 72 Dental Hygiene and Therapy students and 20 Dental Nursing Students. Basic elements of the patient management system remained the same during the expansion; however, additional information was collected and this was more time consuming for practitioners. Clear changes were put in place to facilitate structural expansion and workforce increases; such as double the number of working units. Other changes included, a transformation from collecting patient contribution fees to providing free care to all regardless of their requirement to pay for NHS care, and an amended system to access care through the dental helpline. Finally students were combined into 'practice teams' for combined clinical training for dental and dental care professional students.

The aim of this study was to assess the changes in the demography, including deprivation status, of the patient

**Table 1 – NHS treatment categories in England.**

NHS treatment categories	Description
Band 1 course of treatment	This covers an examination, diagnosis (including X-rays), advice on how to prevent future problems, a scale and polish if needed, and application of fluoride varnish or fissure sealant.
Band 2 course of treatment	This covers everything listed in Band 1 above, plus any further treatment such as fillings, root canal work or removal of teeth.
Band 3 course of treatment	This covers everything listed in Bands 1 and 2 above, plus crowns, dentures and bridges.

Note: NHS payment system in England from April 2006. For further information see NHS Choices – <http://www.nhs.uk/nhsinfo/aboutnhservices/dentists/pages/nhs-dental-charges.aspx>

population accessing an expanded dental facility, and to examine the association of demography and deprivation status on the provision of treatment that included laboratory constructed devices such as dentures, crowns, and bridges.

## Method

Data from the electronic patient management systems of the Dental Academy were extracted and analysed descriptively. The data analysed were at patient level rather than course of treatment or appointment level. The dataset comprised patients with a treatment plan opened and completed/closed in the period twelve months prior to the expansion of services (15th September 2010) and twelve months after, thus covering two academic years. A 'completed' or 'closed' treatment plan is defined as a treatment plan in which all ascribed treatment items have been performed and the plan closed by the dental practitioner or a plan that has been begun with a number of treatment items completed, but due to a patients' failure to attend to the end, has been administratively closed.

Ethical Approval for this research was obtained from National Health Service Research Ethics Committee NRES Committee Fulham REC Reference No. – 11/LQ/1138 Protocol No – N1MHWMOV3.

Patients were informed of the study by a poster placed at various points in the main reception area – both the poster and additional leaflets – which were available on request, informed patients or attendees that they could 'opt out' of having their records used for research. In addition, the patient management system included an 'opt out of research' question posed to patients on registration. Data management was in line with Caldicott and Wellcome Trust Guidelines.<sup>21,22</sup>

The data were extracted with assistance of software providers (Carestream Ltd). The variables analysed were patient age at the beginning of treatment plan, gender ethnicity, payment status (exempt/non-exempt) and indices of multiple deprivation (IMD) (IMD, 2007). IMD was obtained from post code data converted through the Office of National Statistics website.<sup>23</sup> IMD is regularly used in research and health care planning in the UK to analyse patterns of deprivation and identify areas that would benefit from targeted schemes for health.<sup>16,24</sup> This identifies the country's most deprived LSOA's (Lower Super Output Area – a census cluster of about 1500 people). The treatment data were extracted at item level. These were re-coded for each patient into the NHS dental treatment bands; by taking into account the nature of treatments provided in a patient treatment plans. Patients were assigned to the highest band (1, 2 or 3) course of treatment they received within the one year period for the analysis. Data were validated by comparing reports generated from the Local Public Health department's access statistics.

Statistically significant differences in sociodemographic variables between the two periods were tested using  $\chi^2$  and independent sample t-tests. Two logistic regression models were conducted. One to model deprivation measured by IMD against payment exemption status- with the expectation that people with higher IMD scores were more likely to be in the category exempt from charges. The second model was used to assess the likelihood of having treatment that included

laboratory constructed devices e.g. dentures, crowns etc (usually classified under NHS Band 3) in each period, predicted by exemption from payment and other sociodemographic factors.

## Results

### Patient population sociodemography

A total of 4343 patients were seen at the Dental Academy in the 24 month period; between September 1st 2008 and August

**Table 2 – Changes in sociodemographic indicators by academic year 2009/10 and 2010/11.**

Characteristics	Academic year		P value
	Period 1 2009/10 (n = 1749) Number (%)	Period 2 2010/11 (n = 2594) Number (%)	
Gender			
Male	879 (50.3)	1283 (49.5)	0.314
Female	870 (49.7)	1311 (50.5)	
Mean age in years (SD)	31.7 (17.3)	36.4 (19.6)	0.001*
Age groups			
0–2 yrs	20 (1.1)	22 (0.8)	0.001*
3–5 yrs	69 (3.9)	95 (3.7)	
6–12 yrs	154 (8.8)	252 (9.7)	
13–17 yrs	80 (4.6)	98 (3.8)	
18–24 yrs	355 (20.3)	356 (13.7)	
25–34 yrs	386 (22.1)	433 (16.7)	
35–44 yrs	316 (18.1)	405 (15.6)	
45–54 yrs	180 (10.3)	430 (16.6)	
55–64 yrs	100 (5.7)	280 (10.8)	
65–74 yrs	60 (3.4)	138 (5.3)	
75+ yrs	29 (1.7)	85 (3.3)	
IMD score, mean (SD)	24.5 (14.5)	22.3 (13.8)	0.001*
IMD Deprivation quintiles			
1 = lowest deprivation	323 (18.7)	616 (24)	0.001*
2	311 (18)	471 (18.4)	
3	341 (19.7)	525 (20.5)	
4	356 (20.6)	494 (19.3)	
5 = highest deprivation	400 (23.1)	458 (17.9)	
Ethnicity			
White	350 (20)	1401 (54)	0.001*
Black	5 (0.3)	21 (0.8)	
Asian	5 (0.3)	35 (1.3)	
Mixed	1 (0.1)	35 (1.3)	
Other	19 (1.1)	19 (0.7)	
Chinese	3 (0.2)	5 (0.2)	
Unknown	1366 (78.1)	1078 (41.6)	
NHS payment status			
Exempt	755 (43.2)	741 (28.6)	0.001*
Not exempt	994 (56.8)	1853 (71.4)	
NHS treatment bands			
Band 1	604 (34.5)	681 (26.3)	0.001*
Band 2	962 (55)	1481 (57)	
Band 3	145 (8.3)	411 (15.8)	
Urgent	38 (2.2)	21 (0.8)	

\*Significant difference between period 1 and 2  $P = 0.0001$ . Refer to Table 1 for treatment band definitions.



31st 2010. There was an increase of 48.3% in the volume of patients in this study, between the two periods ( $n = 1749$  to  $n = 2594$ ).

Table 2 shows the differences in the sociodemographic characteristics of the patient populations and treatment activity before and after the expansion of services. Treatments are described according to NHS categories as outlined in Table 1. Gender distribution in both periods was the same with a consistent male:female ratio of 1:1. Although there was a high percentage of unreported ethnic status, overall this reduced from 78% to 41.5% in the second period, demonstrating improved reporting. Of the reported ethnicity, white patients were the larger group in both time periods: 350 (20%) and 1401 (54%) respectively. The ratio of adults (18+ years) to children remained static at 4:1. Statistically significant differences were shown in mean age and deprivation scores (IMD) of the patient population ( $P = 0.0001$  for all). Between the two periods, the average age increased from 31.67 (95%CI 30.8–32.5) to 36.4 years (95%CI 35.6–37.1), whilst the range was unchanged (1–94 years). The largest increase in patients was amongst the oldest age group of 75 years and over (196%) and lowest in the 18–24 year olds (0.3% increase). The patient base became less deprived; the mean IMD (deprivation score) of the patient population reduced from 24.5 (95%CI: 23.8, 25.2) to 22.3 (95%CI: 21.7, 22.8) and the proportion of patients who were exempt from payment reduced significantly by 14% (755 of 741;  $P = 0.001$ ). All quintiles of deprivation had a significant increase in the volume of patients  $P = 0.0001$  after expansion; however, the increases were largest in the 1st quintile (least deprived) 90.7% increase, and the lowest increase was in the 5th quintile (most deprived) 14.5% increase.

#### Patient NHS treatment case-mix models

The volume and proportion of treatments within different categories changed between the two periods. Whereas, the proportion of routine dental procedures (NHS Band 2 treatments) was essentially similar in both periods, treatments involving laboratory constructed devices almost doubled (from 8.3% to 15.8%). The proportion of patients receiving assessment/advice treatment only (NHS Band 1 treatments) reduced (from 34.5% to 26.3%) and urgent procedures (2.2%–0.8%) and therefore these procedures reduced by 12% and 44% respectively.

The results of the logistic regression model on the likelihood of experiencing a treatment plan that required a laboratory constructed device (NHS Band 3 treatments) for each period – also referred to as patient treatment case-mix models – are presented in Table 3a. Age, declared ethnicity and being exempt from payment were found to significantly influence the likelihood of having received treatment requiring a laboratory constructed device (NHS band-3 treatment). As the age of patient increases their likelihood of receiving a laboratory constructed device increased when controlling for other variables (declared ethnicity, and payment exemption status); the odds of having received laboratory constructed devices within treatment procedures (NHS Band 3 treatments) increased by 7% in period 1 (95% CI: 1.06, 1.08) and 6% in period 2 (95% CI: 1.05–1.07), for each increasing year of age. It increased by 38% 1.38 (95% CI: 1.01, 1.89) in period 2, for those declaring themselves as white. After adjusting for these effects, in period 1, the odds of having laboratory constructed devices as part of treatment (NHS Band 3 treatments) were almost double for those who were exempt from payment (OR = 2.0; 95% CI 1.34–2.90), while in period 2, the odds of having laboratory constructed devices as part of treatment (NHS band-3 treatment) were 43% higher for those who were exempt from payment (OR = 1.43; 95% CI 1.13–1.81). Thus overall patients who are technically permitted to be exempt charges are more likely to receive laboratory constructed devices as part of treatment but this effect was less marked in the expanded service.

None of the other variables (gender  $P = 0.60$ , social class indicators  $P = 0.76$ , going for urgent treatment  $P = 0.47$ ) or any interaction (age-by-social class  $P = 0.89$ ; exempt-by-ethnicity  $P = 0.39$ ; etc.) was found to have any significant effect on the likelihood of need for treatments that require laboratory constructed devices (NHS Band 3 treatments) in any period. Treatments that include laboratory constructed devices refer to treatments such as denture fabrication, crowns and inlays.

The model on likelihood of exemption (Table 3b) was in turn highly influenced by age, IMD-score and declared ethnicity, in both periods suggesting that people with higher IMD scores were more likely to be in the exempt category from charges. It was also significantly less for men than for women in period 2 (but not in period 1).

**Table 3a – Logistic regression on likelihood of having laboratory constructed devices (NHS Band 3 treatments).**

	Period 1 (2009/10 academic year ( $n = 683$ ))			Period 2 (2010/11 academic year ( $n = 1516$ ))		
	Odds ratio	95% CI	P-value	Odds ratio	95% CI	P-value
Age	1.07	1.06	1.08	1.06	1.05	1.07
Declared ethnicity			NS	1.38	1.01	1.89
White = 1 non-White = 0						0.04*
Exempt from payment	2.0	1.34	2.90	1.43	1.13	1.81
Exempt = 1 non-Exempt = 0			0.001*			0.009*

\*Significant effect  $P < 0.05$ .

NB. The model is consistent when only the adult patient population is modelled.

Declared ethnicity – ethnicity analysed excluding all unstated or unknown ethnicity.

## Discussion

This study highlighted changes in the sociodemographic profile and treatment requirements of patients of an expanded educational primary care dental service. This is shown by the higher influx of patients who were older, less deprived and in need of more laboratory constructed devices as part of treatment; compared to the service users in the period prior to the service expansion.

The expansion of services led to an overall 48% increase in service users who had a treatment plan completed or administratively closed within a year of the specified research period (academic years 2009/10 and 2010/11). This increase in patients with a completed or administratively closed plan can largely be attributed to the increase in the number of dental working stations from 20 to 40 and the fact that more patients were taken on to provide opportunities for student learning. The increases varied within different age groups; with the over 75 years age group having the highest increase (196%). This was unprecedented as the uptake of dental care among older people locally and nationally, is known to be low.<sup>20</sup> The users of the expanded services were less likely to warrant being exempt from NHS charges when compared with users of the previous services, who, when necessary, had to pay a patient-contribution for services. These findings suggest that the provision of the free service improved uptake among groups of patients who previously had to pay. It also suggests, that uptake of care among older groups can be improved by providing an NHS facility such as this, where key barriers to dental care such as cost, are removed, and patients are not required to pay.<sup>25</sup>

The deprivation profile of users changed, with a higher influx of patients from less deprived quintiles (90%) compared to the most deprived quintiles (14.5%). This pattern mirrors findings from other studies and surveys, which revealed poor dental service uptake among deprived groups.<sup>6,20,24</sup> This type of health service access is referred to as the inverse care relationship; where service uptake among those who have less need is higher than those in most need.<sup>26,27</sup> Information regarding new services is regarded as key in improving new service uptake among deprived groups.<sup>18</sup> This expanded service is mainly accessed through a dental helpline, and although this is a measure considered effective in recruiting patients, research suggests that deprived and poorly accessing groups of patients have had continued difficulty in accessing services when the main route to access is a helpline.<sup>19</sup> In order

to increase service use by groups from areas of higher deprivation evidence suggests that tailored health information should be provided and consultations with a range of demographic and user groups should be conducted before services are designed and consequently rolled out.<sup>18</sup>

The patient case-mix models that sought to describe relationships between sociodemography and having treatments that included laboratory constructed devices (NHS Band 3 treatments), provided findings that were similar with research that showed relationship between ageing, increased tooth retention and a need for more complex procedures such as denture fabrication, crowns, inlays and bridges.<sup>13,28</sup> In this study, older patients and non-exempt patients were more likely to have treatments that included laboratory constructed devices (NHS Band 3 treatments) in both periods. The model on exemption status showed that deprivation was a strong indicator of exempt status which is expected as exemption is determined by receipt of social benefits and being under the age of 18 years. The association between being non-exempt from payment and an increased likelihood of having treatment that included a laboratory constructed device (NHS Band 3 treatments), reduced by 57% in the period after expansion. This suggests that changing the service from paying to non-paying may have rendered exemption status as less of a predictor of treatment experience. This is similar to removing the barrier of cost which has been known to determine the nature of dental access.<sup>17</sup>

The findings of this study represent a single large primary care facility, which has a combined educational and service dimension. The findings therefore need to be understood within this dual context. Although the cross-sectional nature of this study, which is associated with the use of patient management system data limits the possibility of looking directly at needs and outcomes, this research provides useful insight into the process of service provision and access especially in the initial period of expansion of a dental service. The findings reiterate ideas that exist on the relationships between service access, service needs and individual factors of dental service users.<sup>6</sup> It is therefore by the monitoring of the patient populations in this way that advances can be made in understanding how best to meet the service needs all populations in need. This service has clearly made inroads towards serving older people and those who would have to pay for services but has struggled to reduce inequality of provision of care overall in its first year of existence. This research is

**Table 3b – Logistic regression modelling the likelihood of being exempt.**

	Period 1 (2009/10 academic year (n = 683))			Period 2 (2010/11 academic year (n = 1516))		
	Odds ratio	[95% CI]	P-value	Odds ratio	[95% CI]	P-value
Gender	0.79	0.64	0.98	0.65	0.48	0.88
Male = 1						
BMD score	1.04	1.03	1.05	1.02	1.01	1.03
Declared ethnicity	0.59	0.46	0.76	1.14	0.84	1.54
White = 1 non-White = 0						
*Significant effect P < 0.05.						
Note: The model is consistent when only the adult patient population is modelled.						
Declared ethnicity – ethnicity analysed excluding all unstated or unknown ethnicity.						



informing Portsmouth Dental Academy's actions to reach into the deprived neighbourhoods.

## Conclusion

The expanded dental services improved service uptake amongst older people within the study sample. The expanded service also showed an increase in the delivery of treatments involving laboratory constructed dental devices. The initial drop in the proportion of deprived populations, demonstrates the importance of local research in determining the best methods to communicate with, and meet the needs of, these groups. The relationship established between demography of patients and changes in treatment needs provides insight for the planning of future service delivery.

## Author statements

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### Ethical approval

Ethical Approval was given by NRES Committee Fulham REC: Reference No – 11/LQ/1138 Protocol No – NIMHWMOV3 and NHS Portsmouth R&D Committee H10W Shared RM & G Services RM & G Reference No – SSPS/05/11. A.

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### Competing interests

None declared.

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### Conference abstracts

1. **Wanyonyi LK**, Radford R David, Gallagher JE. Patient Information Analysis: Patient Case-Mix at the University of Portsmouth Dental Academy. *British Association for the Study of Community Dentistry Presidential Scientific*
2. **Wanyonyi LK**, Radford R David, Gallagher JE. Title: Changing Use of an Expanded Primary Care Dental Training Facility International association of Dental Research General Session Seattle 2013  
<http://iadr.confex.com/iadr/13iags/webprogram/Paper174401.html>
3. **Wanyonyi LK**, Radford R David, Gallagher JE. Title Do dental students in team-training delegate to hygiene therapy students? International association of Dental Research General Session, Cape Town 2014  
<https://iadr.confex.com/iadr/14iags/webprogramschedule/Paper190705.html>